SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1923.

GENERAL PHYSICS.

1. *Passage of Hydrogen through Quartz Glass.* **J. B. Johnson** and **R. C. Burt.** (Optical Soc. America, J. 6. pp. 734–738, Sept., 1922.) —The method used in making the measurements was to observe the pressure rise in an evacuated silica glass tube around which the gas flowed. The furnace consisted of an iron pipe round which was wound a heater of resistance wire and an asbestos covering. A thermo-couple, placed near the centre of the furnace, measured the temperature. Gas, at atmospheric pressure, was passed slowly through the furnace, in which the quartz glass tube was placed axially, and connected to a vacuum pump, gauge, and volume bulb. A measurable leak of hydrogen started at 300° C., and increased rapidly with the temperature. The transfusion begins at the temperature at which structural changes are known to occur in crystalline silica. [See Abs. 1147, 1773 (1915).]
T. C. H.

2. *Simple Model to Illustrate Elastic Hysteresis.* **S. Lees.** (Phil. Mag. 44. pp. 511–537, Sept., 1922.)—The author has here described a simple model which would seem in many ways to bring out, at least qualitatively, many of the general effects observed in connection with elastic hysteresis. The ultimate standpoint is that such effects are due to something analogous to the ordinary solid friction of everyday life. The model enables some simple deductions to be drawn of a mathematical character, but no attempt is made to push these deductions unduly, as the model (involving one dimension of displacement) can only roughly represent what is essentially a question of statistics, involving slippings in all conceivable directions. The paper is largely mathematical, and contains a number of diagrams showing the model or the displacements in question.
E. H. B.

3. *Film Method of Measuring Surface Tension.* **A. W. Fahrenwald.** (Optical Soc. America, J. 6. pp. 722–733, Sept., 1922.)—Several methods are available for measuring surface tension, such as (1) drop-weight, (2) capillary rise, (3) Jaeger or capillary bubble, (4) vibrating jet, (5) measuring tension required to detach ring, sphere, or disc from surface of liquid, (6) film method. The drop-weight method has certain serious objections to it, particularly with oil and water emulsions. The second method requires considerable skill and care; while the third, or Jaeger method, gives more accurate results, but is unsuitable for determining the absorption of oils by minerals. The vibrating jet is entirely unsuitable for general work, and the fifth method always gives values higher than the actual surface tension, entailing the use of a complicated formula to obtain theoretical values. The film method was first used by Mickaelson and Hall, utilising an analytical balance. Now an automatic balance is employed which is accurate to 1/10 dyne per cm. It consists of a knife edge to engage the liquid, not over 0·015 cm. thick, and geometrically as nearly perfect as possible with respect to the point of suspension, made from aluminium, copper, silver, platinum, etc., which have all zero contact angles with water. Projections on it prevent the pulling of the liquid away from the ends of the edge, for which a correction has to be made. The balance proper consists of a main support composed of a tripod stand and a shaft to which is attached a bearing support carrying the swinging member, which is a cork wheel, through which a steel bar 1·5 mm. in diameter passes axially, the ends being ground to knife edges, and resting on steel or glass bearings. Around the periphery of the coils is a **V**-shaped groove in which is hung a No. 50 silk thread, on one end of which is suspended the knife edge forming the liquid film, and on the other a light aluminium pan weighted with fine sand to counterbalance. Fixed on the periphery of the cork wheel is a light aluminium pointer, having a second and very light and short aluminium pointer that maintains a vertical position through all angles of the main pointer. By means of this apparatus a single measurement can be taken in less than two minutes. Interfacial tension can also be determined. [See Abs. 1882 (1921).] T. C. H.

4. *Measurement of a Physical Quantity whose Magnitude is Influenced by Primary Causes beyond Control of the Observer.* **W. A. Shewhart.** (Nat. Acad. Sci., Proc. 8. pp. 248–251, Aug., 1922.) A. B. W.

5. *Electromagnetic Method of Detecting Small Irregularities in Curvature of Spheres and Cylinders: Electromagnetic Control of Oscillations of Mass of Metal for Torsion Experiments.* **A. Marcus.** (Optical Soc. of America, J. 6. pp. 620–624, Aug., 1922.)—If a mass of metal be placed in a uniform alternating magnetic field, so that it can rotate, it is generally supposed that it will remain at rest if it happened to be at rest initially. The author found in the case of a copper ball suspended by means of a torsion fibre, that it started to rotate even when perfectly stationary before the field was thrown on. The effect in different metals was found to be in proportion to the intensity of the "skin effect" for these samples. Experiments with a circular and an elliptic cylinder showed that the torque was much greater in the latter case.

The author suggests that this effect might be used for applying a pure torque in the case of experiments with a torsion pendulum where any mechanical method of starting the oscillations is apt to produce other non-torsional modes of vibration which it is desirable to avoid. J. W. T. W.

6. *Properties and Molecular Structure of Thin Films. Part II: Condensed Films.* **N. K. Adam.** (Roy. Soc., Proc. 101. pp. 452–472, Aug. 1, 1922.)—Further investigations in continuation of the experiments on thin films of palmitic acid described in Part I [see Abs. 280 (1922)] are made in which the range of substances composing the films is extended. The method of making the experiments is described, and the arrangement of the apparatus employed is shown diagrammatically. Curves are given showing the behaviour of the saturated fatty acids C_{14} to C_{22} (excepting C_{19} and C_{20}) on "old distilled water," on fresh distilled water, and on dilute HCl, and show that under similar circumstances all these acids behave identically. The special behaviour with "old distilled water" is noted and discussed. These results, together with those obtained with various esters, alcohols, amides, nitriles, and glycerides are discussed in relation to molecular dimensions, a list of which is given. It is remarked that the presence of the double bond in iso-oleic acid increases the space required by the polar end of the molecule to nearly 15 % more than that occupied by the corresponding polar ends of the molecules of the other fatty acids. A. B. C. L.

7. *A Portable Instrument for Measuring Vibrations in Buildings.* **P. G. Nutting.** (Optical Soc. America, J. 6. pp. 629–632, Aug., 1922.)—The instrument is used for studying vibrations in buildings, due to machinery or traffic, and the amplitudes to be measured lie between 0·001 mm. and 0·1 mm., the former being just perceptible to the hand and the latter decidedly annoying. A lead inertia mass, 20 mm. × 35 mm. in section, and 6 in. long, is attached in a vertical position to the centre of a horizontal diaphragm 1/32 in. thick of some light material, such as bakelite micarta, which is firmly held round the edges between the two halves of a hollow circular box, 6 in. in diameter and 1 in. thick, the interior of which is ½ in. deep and 5 in. in diameter. At the head of the lead weight is a brass block of the same section, carrying on either side a glass plate in a milled recess. The outside surfaces of these plates are exactly parallel to one another and to two other glass plates, which are rigidly connected to the box below by the two heavy L-shaped uprights of heavy strap brass which carry them, and which are joined at the top by a heavy brass top plate. The distance between the two pairs of parallel glass plates on either side of the instrument is about one mm. and a horizontal steel roller, the diameter of which is equal to this distance, is slipped between the glass plates on either side. Each of these rollers carries at its end a galvanometer mirror, and when the box forming the base of the instrument is placed on a support which vibrates vertically, each downward motion of the support moves the box, the L brass uprights and the two glass plates they support downwards, while the lead inertia mass tends to remain at rest; the rollers and the mirrors attached turn, one clockwise and the other anti-clockwise, and a beam of light reflected from one to the other is deflected, so that the resulting light spot moves up and down, reproducing the vibrations magnified. The instrument may be held in the hand against a vibrating wall, and will then show horizontal vibrations. H. N. A.

8. *On the Viscosity and Molecular Dimensions of Sulphur Dioxide.* **C. J. Smith.** (Phil. Mag. 44. pp. 508–511, Sept., 1922.)—Langmuir has suggested a possible arrangement of the atoms which constitute the SO_2 molecule [Abs. 272 (1922)]. As recent work on the viscous properties of gaseous compounds has been successful in elucidating their molecular structure, and as the viscosity data of SO_2 were very scanty, the measure-

ments described were undertaken. The same method was used as with silicane [Abs. 1808 (1922)], observations having been made at atmospheric and steam temperatures. Sutherland's constant was found to be 416, and $\eta_0 = 1{\cdot}183 \times 10^{-4}$ c.g.s. units. The mean area which the molecule presents in mutual collision with others is found, by Chapman's formula, to be equal to $0{\cdot}94 \times 10^{-15}$ cm.^{2}. The actual experimental error may be taken as about 2 or 3 %. Owing, however, to the comparatively small temperature range there is no proof that Sutherland's law holds.
H. N. A.

9. *Electronic Structures of Crystals.* **M. L. Huggins.** (Am. Chem. Soc., J. 44. pp. 1841–1850, Sept., 1922.)—In another article the author has extended the Lewis theory of atomic structure [Abs. 946 (1916)] to include all the elements, grouping the electrons round a nucleus at the corners of more or less regular polyhedra; each group of 2 or 3 electrons, except those belonging to the inner polyhedron, occupying a position opposite a face of the next inner shell. When two atoms are joined by a single bond the bond electron pair tends to place itself on, or near, the straight line joining the atomic centres, and opposite a face of the outermost kernel polyhedron of each of the two atoms. In a large number of crystals the atoms are joined by single bonds of this type.

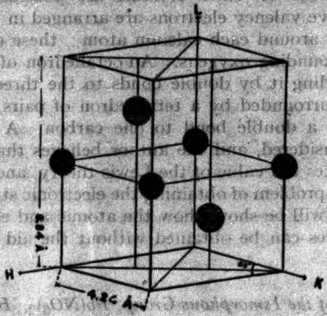
Diamond.—Each atom is symmetrically surrounded by four others at tetrahedron corners. Each carbon atom has four valency electrons, which tend to be arranged at the corners of a tetrahedron round the nucleus, pairing when possible with single electrons from other atoms to form an octet round the atom. In diamond these valency electrons are in pairs, midway between adjacent atoms, and each atom is held in place by four carbon-carbon single bonds. *Silicon.*—According to the author's theory, silicon has the following electronic structure: $(+14)(2 \times 1)(4 \times 2)(4)$. The first parenthesis, in this and following structural formulæ, encloses the nuclear charge, the last the number of valency electrons, and those between indicate the number of groups, and the number of electrons in each group, in each kernal shell, in order, from the nucleus outwards. In this case the first shell has two electrons, the next has eight electrons, arranged in groups of two at the corners of a tetrahedron, and there are four valency electrons outside this, opposite the faces of the tetrahedron. Silicon forms crystals in which the atoms are arranged exactly as in the diamond. The same is true of germanium and grey tin, the structures of each of which are given in the paper, and show a similar arrangement of the valency electrons. The cubic crystals of zinc sulphide, cuprous chloride, bromide and iodide, and of silver iodide, have structures like that of diamond; but half the carbon atoms are replaced by metal atoms, and half by sulphur or halogen atoms, arranged so that each electropositive atom is symmetrically surrounded by four electronegative atoms, and *vice versa.* The atomic formulæ giving the distribution of the electrons in the atoms of each of the elements involved is given, and in each case the outermost kernel shell is a tetrahedron.

In each of the above compounds there are eight valency electrons per molecule; or an average of four per atom; and these arrange themselves as in the case of the diamond. The hexagonal crystals of zinc sulphide, zinc oxide, cadmium sulphide, and silver iodide have very similar atomic arrangements, each metal atom being surrounded by four, practically equidistant, tetrahedrally disposed oxygen, sulphur, or iodine atoms, and *vice versa*. The atomic formula of an element varies in different crystals. Copper is $(+29)(2 \times 1)(6 \times 3)(4 \times 2)(1)$ in cuprous chloride, and probably $(+29)(2 \times 1)(5 \times 3 + 1 \times 2)(4 \times 2)(2)$ in chalcopyrite, $CuFeS_2$. Iron is $(+26)(2 \times 1)(2 \times 3 + 4 \times 2)(4 \times 2)(2)$ in the last-named crystals, and $(+26)(2 \times 1)(6 \times 3 + 2 \times 2)(2)$ in pyrites, the cubic form of iron disulphide, in which each iron atom is surrounded by six sulphur atoms, at the corners of a nearly regular octahedron, and each sulphur by four tetrahedrally disposed atoms, three being iron and one sulphur. The six groups of three electrons, and two groups of two, in the third parenthesis of the above formula, are at the corners of a cube, opposite the faces of which the six sulphur atoms are situated. A number of other crystals are considered. In calcite it appears that twelve valency electrons are arranged in pairs at the corners of an octahedron, around each calcium atom; these connect it by single bonds to the surrounding oxygens. An octahedron of pairs is also round each carbon, bonding it by double bonds to the three oxygens about it. Each oxygen is surrounded by a tetrahedron of pairs, bonding it to two calciums, and by a double bond to one carbon. A number of similar structures are considered, and the author believes that the investigation amply demonstrates the value of the Lewis theory, and his own extension of the same to the problem of obtaining the electronic structures of crystals. In later papers it will be shown how the atomic and electronic structures of many substances can be obtained without the aid of X-ray measurements. H. N. A.

10. *Structure of the Ismorphous Group, $Pb(NO_3)_2$, $Ba(NO_3)_2$, $Sr(NO_3)_2$, $Ca(NO_3)_2$.* **L. Vegard.** (Zeits. f. Physik, 9. 6. pp. 395–410, 1922.)—The space lattice of this group has been determined by means of the powder method. The crystals are not composed solely of homogeneous face-centred lattices, but the reflection maxima of such lattices increase with the atomic weight of the metal, so that the metallic atoms are arranged in a face-centred lattice. One nitrogen atom and three oxygen atoms form a group at four corners of a cube, this group being surrounded by four atoms of the metal. In these compounds the atoms occupy a greater space than in those on which Bragg's investigations were based, the atomic radii varying considerably with the nature of the chemical linking and with the geometrical arrangement of the atoms.

The density of a pure solid compound may often be determined with advantage by the Röntgen-ray method, with which pulverulent material may be employed and also appreciably impure material, since the lattice constant of a crystalline substance is modified but slightly by the presence of impurities. T. H. P.

11. *The Crystal Structure of Cadmium Iodide.* **R. M. Bozorth.** (Am. Chem. Soc., J. 44. pp. 2232–2236, Oct., 1922.)—According to Groth, cadmium iodide crystals are hexagonal. Photographs of line spectra were taken with X-rays from a rhodium target, using the principal faces of the crystal, and by the Laue method, with the beam approximately perpendicular to a (001) plane; and measurements were taken for the rhodium α_1 line, $\lambda = 0{\cdot}6121$ Å. The dimensions of the hexagonal unit of structure are height 6·84 Å., side of base 4·24 Å. (see diagram). Taking the density as 5·644 the parallelopiped would contain 0·995 molecules. A symmetrical Laue photograph showed that cadmium iodide is not hexagonal, but trigonal, and measurements of the intensities of the (001) reflections showed that the arrangement of the atoms was as shown in the diagram, where the black spots represent cadmium atoms and the shaded spots iodine atoms. In arriving at this result it was assumed that the reflecting powers of the atoms are proportional to their atomic numbers; but with any reasonable assumption regarding reflecting power the atoms would be placed close to the positions shown. The shortest distance between the centres of the cadmium and iodine atoms is 3·00 Å. which is exactly the sum of W. L. Bragg's radii for these atoms. The iodine atoms are also "in contact" on the Bragg hypothesis. The shortest distance between their centres is 4·21 Å., while Bragg's "diameter" for this atom is 2·88. The separation indicates that atoms charged with the same sign are farther apart than Bragg's hypothesis indicates, though technically "in contact." **H. N. A.**



12. *Spectra of X-Rays and the Theory of Atomic Structure.* **D. Coster.** (Phil. Mag. 44. pp. 546–573, Sept., 1922.)—*Part* IV. *New Measurements in the L-Series of the Elements La* (57)–*Lu* (71).—This paper has been divided into 5 parts: Parts I, II, and III have already been published [see Abs. 2206 (1922)]. In Part I the general laws governing the emission of the characteristic X-ray spectrum have been dealt with, and the relation between these laws and Bohr's theory of atomic structure have been discussed.

Parts II and IV contain new experimental results, Part II gives the new measurements in the L-series of the elements Rb–Ba, Part IV those of the elements La–Lu. These measurements comprise: (1) A great number of lines which may be arranged in a simple diagram, these are denoted as diagram lines, and (2) some non-diagram lines, (3) some absorption discontinuities.

Parts III and V give a theoretical discussion of the new measurements. From this discussion it appears that the new results as regards the diagram lines are in good agreement with Bohr's theory as regards the successive development of the shells of electrons in the atom. According to Bohr at different stages of the periodic table we meet with atoms for which an inner shell of electrons is completed. Thus the M-shell is completed in the neighbourhood of the iron group, the inner N-shell is partly completed in the region of the Pd group, and again definitely for the rare-earth metals. The appearance of the Pt metals is connected with the partial completion of the inner O-shell. This conception is found to be in agreement with the experimental results. Again, according to Bohr, we must expect, when an inner shell is completed, that the most loosely bound electrons of this shell are bound not more firmly than the valency electrons belonging to the outermost shell. From the experimental data of the present paper this can be shown to be really the case.

A. B. W.

13. *Crystal Structure of Beryllium and Beryllium Oxide.* **L. W. McKeehan.** (Nat. Acad. Sci., Proc. 8. pp. 270–274, Sept., 1922.)—A thin-walled pyrex glass tube about 1 mm. in diam. was packed loosely with beryllium powder, the looseness of packing being intended to reduce the chance of anisotropy. An intense source of X-rays was employed and an exposure of about 18 hours was given. In taking the photograph used for measurement the sample was rotated about its axis through a small angle at intervals of one hour. In order to eliminate from consideration any lines certainly due to the presence of BeO, a sample of that substance in the form of a fine powder was examined in the same way. The tabulated results thus obtained show that the diffracting centres lie at the points of two symmetrically penetrating hexagonal space lattices, each with the axial ratio $c/a = 1\cdot63$ and with $a = 2\cdot696 \times 10^{-8}$ cm. Assuming that one molecule, BeO, is associated with each lattice point and taking $N = 6\cdot0594 \times 10^{23}$ [Abs. 123 (1920)], $w = 9\cdot018$, this gives a computed density of 2·99 gm./cm.^{3}. Both structure and density are in agreement with published values, though a recent paper by Gerlach contains a very different result. The resolving power of his apparatus was, however, not high, and all the lines which he reported as intense are within a short distance of positions accountable for by the structure here proposed. The results for beryllium show that the diffracting points form two symmetrically interpenetrating hexagonal space lattices, each with the axial ratio $c/a = 1\cdot58$, and with $a = 2\cdot283 \times 10^{-8}$ cm. No lines are left unaccounted for by this structure, which is consistent with the hexagonal structure ($c/a = 1\cdot5802$) determined by optical methods. Assuming one atom to be associated with each lattice point and with the above values for N and w, this gives a computed density of 1·827 gm./cm.^{3}, which is about 1 % less than the best previous values. Comparing the proposed structure for Be with those previously reported for elements in the same column of the periodic table, it is clear that it belongs rather to Mg, Zn, and Cd than to Ca, Sr, and Ba, the first three being hexagonal, all with c/a greater than 1·58 and increasing with the atomic number, whereas Ca, the only member of the second three which has been analysed, has cubic symmetry. The oxide BeO has an analogue in ZnO, all the other monoxides having cubic symmetry, except HgO which forms monoclinic crystals.

A. W.

14. *Crystal Structure of Potassium.* **L. W. McKeehan.** (Nat. Acad. Sci., Proc. 8. pp. 254–255, Aug., 1922.)—Potassium, when examined by X-rays at room temperature, appears to be amorphous. If, however, potassium cast in a thin-walled glass tube is cooled to −150° C., large crystals giving well-marked reflections of the K-radiation of molybdenum are formed. The observations with such a crystal indicate that the atoms are arranged in a body-centred cubic lattice with $a = 5\cdot20 \times 10^{-8}$ cm., and therefore with a density 0·92 gm./cm.^{3}. This value is higher than the commonly accepted value 0·862 gm./cm.^{3}, partly, no doubt, on account of the low temperature of the crystals. **A. B. W.**

15. *Viscous Properties of CO_2, N_2O, CO, and N_2.* **C. J. Smith.** (Phys. Soc., Proc. **34.** pp. 155–163; Disc., 163–165, June, 1922.)—Langmuir has called attention to the fact that the viscosities of N_2 and CO are approximately equal at 0° C, and considers that this evidence should be sufficient to prove that the structure of the outer shell of these molecules is nearly the same. Similar considerations apply to CO_2 and N_2O; but in neither case is the conclusion justified unless the viscosities are equal at *all* temperatures; the viscosity at any particular temperature and the rate of change of viscosity with temperature being the same for each gas in a pair. Measurements have been made at 15° C. and 100° C. by A. O. Rankine's method [see Abs. 1387 (1910), 271 (1922)]. It is shown that the capillary effect can be almost if not entirely eliminated, by making double sets of time observations; first with the mercury pellet which drives the gas through a capillary tube intact, and then with it broken into two segments, each approximately half the whole pellet. The ratio between the mean values of the corrected times of fall of the pellet with CO_2 and N_2O was 1·001 at 15°, and 1·003 at 100°; with CO and N_2 it was 1·000 at 15°, and 1·001 at 100°; or the viscous properties of these pairs of gases are practically identical. Sutherland's constants for CO_2 and N_2O is 274, and for CO and N_2 118, if Sutherland's law is valid for these gases. The viscosities have been determined in c.g.s. units by comparison with air. At 15° the viscosity of CO_2 and N_2O is 1·441; 100°, 1·845; 0·0°, 1·366; CO and N_2; 15°, 1·737; 100°, 2·118; 0·0°, 1·665. The mean collision areas from Chapman's formula are $A = 0{\cdot}834 \times 10^{-15}$ sq. cm. for CO_2 and N_2O, $A = 0{\cdot}767 \times 10^{-15}$ sq. cm. for CO and N_2. These pairs of gases have equal molecular weights, CO_2 and N_2O 44, CO and N_2 28, and equal numbers of extra nuclear electrons, CO_2 and N_2O 16, CO and N_2 10. The equalities of apparent molecular size which have been indicated do not of themselves prove any special electronic arrangement, but merely suggest that the arrangements are nearly identical. Even if the electrons are distributed in an identical manner in these pairs, the molecular moments of inertia will be unequal on account of the differing masses of the atoms in the molecules. It seems probable that the spectroscopic method, applied by Imes and others to the gaseous hydrogen halides would lead to the discovery of such differences of rotational inertia. This would involve the measurement of the far infra-red absorption spectra of the gases in question, and the treatment of the results in terms of the quantum theory. *Discussion.*—**A. O. Rankine.** The ratios of the viscosities have a very great accuracy since they are the ratios of times which are nearly equal. The absolute viscosities depend on the calibration of the stop watch. It appears that the chemical and physiological properties of these gases depend, not on the outer electron system, but on the distribution of the nuclei. **F. L. Hopwood.** The physiological properties probably depend on the configuration of the atoms, or the shape of the molecule. The author's results give a measure of the mean collision area of the molecule and not necessarily any information about its configuration. **The Author.** Sutherland's constant C($\eta = kT^{\frac{1}{2}}/(1 + C/T)$, k = const. T = abs. temp.) is clearly a temperature, and is proportional to the work done in separating two molecules in contact to an infinite distance. Oxley has called attention to the fact that the specific susceptibilities of CO_2 and N_2O are

$-0{\cdot}423 \times 10^{-6}$ and $0{\cdot}429 \times 10^{-6}$, and their molecular susceptibilities $-18{\cdot}6 \times 10^{-6}$ and $-18{\cdot}8 \times 10^{-6}$. Also that, while the electron systems of the two molecules appear to be indentical, the net positive charges on the nuclei are 8–6–8 for CO_2 and 7–8–7 for N_2O; so that if atomic nuclei possess rotations and are a source of magnetic moment, it must be assumed that the redistribution of the positive charges in the manner indicated involves no change of angular momentum. H. N. A.

16. *Viscosity Determinations by Means of Orifices and Short Tubes.* **W. N. Bond.** (Phys. Soc., Proc. 34. pp. 139–143; Disc., 143–144, June, 1922.)—For rates of flow less than a certain critical value the flow at the ends, when the liquid flows out not into the air, but into a second vessel of liquid, will be purely viscous, and the end correction will be proportional to the rate of flow. It is shown that if two tubes of lengths l_1 and l_2, each with internal radius r, are adjusted for equal flow Q per sec., by making the total pressures p_1 and p_2, that since $p_1 = l_1 \,.\, dp/dl + p_e$; $p_2 = l_2 \,.\, dp/dl + p_e$; where dp/dl is the pressure gradient causing flow at parts of the tube distant from either end, and p_e is the excess of pressure difference required for the ends: it follows that $p_e = (l_1p_2 - l_2p_1)/(l_1 - l_2)$, and $dp/dl = (p_1 - p_2)/(l_1 - l_2)$. Using the method of dimensions $p_e = Q^2\rho/r^4 \,.\, \phi_4(Q\rho/r\mu)$, and for parts of the tube distant from the ends $dp/dl = Q^2\rho/r^5 \,.\, f_4(Q\rho/r\mu)$, where ρ is the density and μ the viscosity. When the pressure differences are independent of the viscosity, in turbulent flow, f_4 and ϕ_4 are constant: $p_e = Q\mu/r^3 \,.\, \phi_3$, $dp/dl = Q\mu/r^4 \,.\, f_3$ for purely viscous flow, where ϕ_3 and f_3 are constants. Mixtures of glycerine and water were used in all the experiments, which were carried out with different pairs of tubes, the method being almost identical with that used in experiments on an orifice [Abs. 24 (1922)]. For purely viscous flow the results indicate that $p_e = Q\mu/r^3 \,.\, (2{\cdot}92 \pm 0{\cdot}05)$. The results are plotted by taking $\sqrt{Q\rho/r\mu}$ for abcissæ and $Q/r^2 \times \sqrt{\rho/p_e}$ for ordinates, and show a straight portion, sloping up from the origin for viscous flow through the tube and at the ends; a portion bending over towards the horizontal for viscous flow through the tube and turbulent flow at the ends; a sudden upward bend where the flow in the tube begins to get turbulent, the curve bending down again towards the horizontal as the turbulence becomes more complete. The values in the last stage lie well between the range of values usually quoted as applying to the end effects for large pipes. The flow is purely viscous at all points if $Q\rho/r\mu < 16$, and the viscosity is then $\mu = \pi r^4 p/8Q(l + 2\,kr)$, where $k = 0{\cdot}573 \pm 0{\cdot}009$. This enables the viscosity to be determined with quite short tubes, or even orifices made by drilling a hole in a plate; in other cases moderately long tubes must be used, otherwise the kinetic end effect may become larger than the main term being measured, and the flow in the tube may become turbulent. *Discussion.*—**A. O. Rankine** asked if there was any reason why a long tube should not be used to reduce error due to end-corrections. **J. S. G. Thomas.** When employing a variable head it is not in general accurate to use the mean value of the head in calculating the absolute value of the viscosity. In commercial types of viscometer, with a short tube, the efflux occurs into air; Higgins has compared two of these with a long capillary tube viscometer, and it would be interesting to know whether the author's results agree. For the efflux of gases through orifices in plates the phenomena at the exit are important as also the thickness of the plate. **The Author.** The use of a short tube has advantages in

the case of a very viscous liquid, as the apparatus can be made small, and it is easier to keep the temperature constant. The deviation of the value of the end correction given by Lidstone assumes that the viscous loss of energy and the kinetic energy removed from the system at emergence act independently. This leads to the conclusion, pointed out by Edser, that the pressure difference between the upper reservoir and the emergent liquid varies with the distance of the stream line from the axis of the tube, which is almost certainly erroneous. Errors due to the variable head do not affect the present experiments, as this was taken into account where necessary. The results have not been compared with any in which the liquid flows into air. Experiments in which gases are used cannot be compared with those on viscous liquids, unless the variation in density of the gas is negligible. H. N. A.

17. *Analysis of the Electronic Structure of the Elements.* **A. Dauvillier.** (J. de Physique et le Radium, 3. pp. 221–251, July, 1922.)—In previous publications [see Abs. 322, 574 (1922)] the authors have studied in detail the L series of the elements U, Au, Pt, Ir, Os, W, and Sb and the K series of copper and of the molybdenum—doubling the number of lines then known and rectifying certain errors which made it otherwise impossible to apply Sommerfeld's theory. The observations now described have made it possible to define the majority of the centres of energy in these atoms, giving a complete qualitative representation of their absorption spectra. The results have been applied to the calculation of the ionisation potentials of the gases and of metallic vapours. The number of electrons in the various corpuscular envelopes of the elements has also been calculated from the experimental data. A relation of great simplicity has been observed between this number of electrons and their characteristic number of quanta. This law explains the character of the periodic table. The authors suggest a hypothesis accounting for the complexity of the K and L series of the light elements and making it possible to connect the X-ray spectra with the luminous spectra. A. B. W.

18. *Neuburger's Model Atomic Nucleus.* **F. P. Valeras.** (Phys. Zeits. 23. pp. 304–305, Aug. 1, 1922.)—The atomic models due to Meitner and to Neuburger [Abs. 1737 (1922)] are discussed. The former is rejected, and the latter is stated to be dependent on the existence of isohelium. A new model nucleus is proposed. A. W.

19. *Model Atomic Nucleus.* **M. C. Neuburger.** (Phys. Zeits. 23. pp. 305–309, Aug. 1, 1922.)—A criticism of Valeras' paper [see preceding Abs.]. Neuburger states that the existence or non-existence of isohelium is of no importance as regards his proposed nucleus [Abs. 1737 (1922)], which is confirmed by experiment. The model proposed by Valeras is not new and does not apply in many cases. A. W.

20. *Doppler's Principle and Bohr's Frequency Condition.* **E. Schrödinger.** (Phys. Zeits. 23. pp. 301–303, Aug. 1, 1922.)—A mathematical paper following up the work of Försterling [Abs. 597 (1921)]. A frequency formula is obtained which differs from the usual relativistic Doppler formula only in the fact that the factor of the observed frequency is the geometric mean of the values obtained for the initial and final velocities of the molecule. A. W.

21. *Model Atomic Nucleus.* **L. Meitner.** (Phys. Zeits. 23. p. 305, Aug. 1, 1922.)—A brief criticism of the paper by Valeras [see Abs. 18 (1923)], in which it is pointed out (1) that Meitner has never put forward a model nucleus of general application, and (2) that the model proposed by Valeras does not agree with radio-active phenomena. A. W.

22. *Einstein-de Haas Effect.* **W. Braunbek.** (Phys. Zeits. 23. pp. 307–309, Aug. 1, 1922.)—The factor *k* introduced as the result of experiment into the theoretical formula for the Einstein-de Haas effect [see Abs. 1123 (1915) and 898 (1920)] is in the present paper shown to be explained by the assumption of an atomic nucleus with rotating constituent parts. The experimental determination of the value of *k* thus furnishes information concerning mean values of the impulse momenta in the respective atoms. It is shown that the value of *k* for all ferromagnetic substances is probably exactly equal to $\frac{1}{2}$, so that in these atoms the impulse momentum of the nucleus and of the whole atom are the same, the value for most atoms being $h/2\pi$. A. W.

23. *The Model of the Hydrogen Molecule Ion.* **W. Pauli, Jr.** (Ann. d. Physik, 68. 3. pp. 177–240, Aug. 3, 1922.)—The existence of H_2', composed of two nuclei and one electron, is observed during the passage of canal rays through hydrogen. On standing, the group breaks down only slowly into a neutral atom H and a charged atom H′. From a consideration of the respective ionisation potentials the energy content of H_2' is greater than that of the H atom, so that the process $H_2 \longrightarrow H + H'$ takes place with evolution of energy. On account of the dynamic stability of the molecule the decomposition does not take place spontaneously, however, but may be brought about by electronic collision. H_2 is therefore to be regarded as metastable, while the ionisation potential required for its formation is higher than that needed to give H and H′. This property is in accordance with the simplest structural model for H_2' in which the electron rotates in a circular orbit in a dividing plane between the two nuclei. A discussion is given of the possibility of calculating from this rotational system the multiple line spark system given by H_2. J. N. P.

24. *Relativity Contraction of Rotating Shaft Moving Uniformly Along its Axis.* **F. E. Hackett.** (Phil. Mag. 44. pp. 740–752, Oct., 1922. Paper read before the British Assoc., Sept., 1921.)—The author assumes a fixed ether and the Fitzgerald-Lorentz contraction; restricted relativity; that the elastic constants are infinite (eliminating the effects of centrifugal force); and Euclidean space. The last condition involves the assumption that each cross-section of the shaft remains a Euclidean plane, so that its radius alters in the same ratio as the circumference, and the further assumption that one of the principal axes of strain lies along the radius. The other two must then lie in a plane normal to the radius. The author further assumes, on the basis of analogy to the Wiedemann effect, that one of the latter lies along the direction of resultant velocity. He obtains the respective contractions $(1 - v^2/c^2 - u^2/c^2)^{1/2}$, $(1 - v^2/c^2 - u^2/c^2)^{1/2}/(1 - v^2/c^2)^{\frac{1}{2}}$, $(1 - v^2/c^2)^{1/2}$, in the directions of the resultant, the circumferential and the longitudinal velocities, where *v* is the uniform motion of translation of the shaft and *u* is the rotational speed at its periphery, both being measured by a fixed observer. The limiting case of $v = 0$ gives the case of a rotating disc so that the author's conclusions in this case are that :—(1) The radius and the circumference of a solid disc rotating with constant speed about an axis at right angles to its plane contract in the ratio of 1 to $(1 - u^2/c^2)^{1/2}$, where u is the velocity at the rim. (2) A measuring rod laid along the radius contracts in the ratio of 1 to $(1 - u_1^2/c^2)^{3/2}$, where u_1 is the velocity at that position in the disc. The author refers to the fact that Lorentz found [Abs. 1201 (1921)] that both radius and circumference contract in the ratio of 1 to $1 - u^2/8c^2$. [Lorentz assumed, as does the author, a real Lorentz-Fitzgerald contraction in a fixed ether, and infinite elastic constants for the disc, and obtained his result by adapting the ordinary theory of elasticity to the general relativity theory, in a field free from gravitation, and working out the case of a thin circular disc.] G. W. DE T.

25. *Rest Mass, and Mass Due to Motion in Static Gravitation Field.* **G. Jaffé.** (Phys. Zeits. 20. pp. 337–340, Sept. 1, 1922.)—Although mass variation in a gravitation field is fundamental in general relativity, the author shows by examples (Einstein, Laue, Thirring) that there is no agreed method of expressing their relation in any given case. Assume a static gravitation field in part of which the metric closely approximates to the pseudo-Euclidean and a small test body of mass m_0 when at rest or slowly moving in this part, and the reaction of which on the field is negligible. The problem proposed is to determine m, the mass due to motion, at small velocity, when brought into a field defined by $ds^2 = -A((dx^1)^2 + (dx^2)^2 + (dx^3)^2) + B(dx^4)^2 \ldots (1)$. In restricted relativity m_0 and m are perfectly definite, and their relation indicates expression in terms of the momenta. Take then Einstein's expression [Abs. 906 (1918)] $\mathbf{J}_i = \int \mathbf{U}_i^0 dx^1 dx^2 dx^3$ $(i = 1, 2, 3, 4) \ldots (2)$ where $\mathbf{U}_i^k = \mathbf{T}_i^k + \mathbf{t}_i^k \ldots$ (2A) the respective energy components of matter and of the gravitation field. $\mathbf{J}_1$, $\mathbf{J}_2$, $\mathbf{J}_3$ are thus the negative momenta of the isolated system, and $\mathbf{J}_4$ is its total energy on the assumptions that it is contained within a world cylinder outside which the metric has constant coefficients; that the space x^4 is a constant finite section of the world cylinder; that the integration in (2) is taken over such a section. Suppose, further, the section taken to be large relative to the test body, and the latter far from where there is sensible field variation. Then [H. Weyl, Abs. 1963 (1921)] the relations become those of the restricted theory of $\mathbf{T}_i^k = \mu u_i u^k$, where $u^i = \partial x^i/ds \ldots (3)$ and the rest mass density μ is related to the invariant mass element dm_0 by the equation $dm_0 ds = \mu dx^1 dx^2 dx^3 dx^4 \ldots$ (3A). Now $\mathbf{t}_i^k = 0 \ldots (4)$, since the test body reaction is negligible, and if all its particles have a common velocity u^i, it follows from (2), (2A), (3), (3A), and (4) that $\mathbf{J}_i = m_0 \mathbf{u}_i = m_0 g_{ik} u^k \ldots (5)$ in which the test body's relation to its immediate environment disappears, since $\mathbf{u}_i$ is a vector in any coordinate system. And since the gravitation field is static, $ds^2 = -d\sigma^2 + g_{44} dt^2$, and $d\sigma^2 = \gamma_{ik} dx^i dx^k$, $i, k = 1, 2, 3 \ldots (6)$ where g_{44} and the γ_{ik} are independent of the time. Thus throughout there is one *cosmic*, or better, *static* time, indicated by clocks in the pseudo-Euclidean parts of the field. Changing, by (6), the independent variable from s to t, in (5), $\mathbf{J}_i = m_0 \gamma_{ik} \dot{x}^k/(g_{44} - \dot{\sigma}^2)^{1/2}$, $i = 1, 2, 3) \ldots (7)$ $\mathbf{J}_4 = m_0 g_{44}/(g_{44} - \dot{\sigma}^2)^{1/2} \ldots (8)$. Then (8) is the generalisation of the restricted theory expression for the energy of a moving particle starting with rest mass m_0, and $\dot{\sigma}$, the velocity in natural length units and cosmic time, is a static invariant. For a particle at rest $\dot{m}_0 = m_0\sqrt{g_{44}}$, and $\dot{m}_0$, a static invariant which may be called *static mass*. It coincides with m_0 only when the light velocity is unity. Equation (7) shows that the mass due to motion in a static gravitation field is no longer a scalar, but a symmetric tensor of the second kind in strained space, with the covariant components $m_{ik} = m_0\gamma_{ik}/(g_{44} - \dot{\sigma}^2)^{\frac{1}{2}}$. The light which this solution throws on the discrepancies referred to is a part only of the author's claim that it is the true solution. G. W. DE T.

26. *Relativistic Mechanics of Radiation.* **A. Bramley.** (Phil. Mag. 44. pp. 720–728, Oct., 1922.)—If energy possesses mass, the laws of radiation should be expressible in mechanical and electrodynamic terms. The author assumes a system in uniform motion specified by the fundamental electrodynamic equations in terms of $\mathbf{E}$, $\mathbf{H}$, ϕ, $\mathbf{U}$, and supposes the charged system to rotate uniformly in the XY plane around the original centre. The equations are first transformed to coordinates moving with the charge, $x = r\cos\theta$, $y = r\sin\theta$, where $\theta = \omega t$. The oscillations are assumed so small that $\dot{\omega} = kt^{-2}$ and the time during which an electron is oscillating so great that $kt^{-1} < \omega$, i.e. that $\partial^2/\partial t^2 = \omega^2\partial^2/\partial\theta^2$. Also, ϕ is replaced by $\phi\sqrt{1-\beta^2} \equiv \phi_1$, $U_\theta = \beta\phi$, $U_r = U_x = 0$, while $H_\theta = 0$; and for the contractile electron ϕ_1 is symmetrical in the distorted space of the fixed system and equal to $e/4\pi r_1$, where r_1 is the distance from the centre of the sphere in this system. If P (x, y, z) be a point in space in the XY plane, r_0 the projection of r_1 on that plane, and θ_1 the angle POE, where E is the position of the electron whose orbital radius is R, then

$$r_1 = (r^2 + R^2 + Z^2 - 2rR\cos\theta_1)^{\frac{1}{2}},$$

which gives ϕ_1 and its three partial derivatives. Hence are obtained E_R, E_Z, E_θ; also H_Z and H_R. The calculated values of H and E along the axis of revolution agree with those found by other methods except for the terms involving acceleration, and this portion of the force varies as the inverse square of the distance of the point from the moving charge, and therefore vanishes at great distances. The accelerations are involved in E_θ and H_R, showing that the part of the electromagnetic field depending on the acceleration $\dot{u}$ of the particle is specified by the two vectors $\mathbf{H}$ and $\mathbf{E}$, which are mutually perpendicular but differ in magnitude unless $u = c$; the forces here vary inversely as the distance, so that at great distances from the moving charge the effect of acceleration becomes preponderant. The density of the energy stream at any point is $c[\mathbf{EH}]$, and is along the Z-axis. The high-speed electrons are seen to be the most efficient radiators. For an electron consisting of a perfectly conducting sphere surrounded by a changed shell of uniform surface density no energy would be radiated inwardly and each element of the electronic shell would radiate the same amount of energy.

If electronic energy possesses mass there should be equilibrium between the attraction and radiation forces, so that the energy would condense around the electron until this is obtained, when it will be emitted in quanta. The force density on a volume element due to radiated energy is $-\partial/\partial t[\mathbf{EH}]$ and the energy radiated is $c[E.H.]$; hence force on unit energy density $= \partial/\partial t\left\{\log[EH]\right\}/c$, and per unit of mass $= c/2 - \partial/\partial t\left\{\log[\mathbf{EH}]\right\}$. Now $\partial/\partial a\int\int\int p r\gamma/h\,.\,ds\,d\phi\,dr = c\partial/\partial t\log[\mathbf{EH}]$, and this mass is similar to that due to charged particles, so cannot be Newtonian gravitation but rather the electrostatic force; therefore $4\pi\gamma\rho a = 4\cdot 1/10^{40}\partial/\partial t \log [\mathrm{EH}]ac$, where ρ is the density and da the thickness of the shell. And $\mathrm{M} = 4\pi a^2\rho da = 2\mathrm{E}/c^2$, where E is the total energy condensed, and since frequency $2\pi nu = \omega, \mathrm{E} = c^3/\nu \,.\, 4\cdot 1/10^{40} \,.\, 2\pi a^2/4 \,.\, nu$, which gives $h = 6\cdot 57 \times 10^{-7}$, taking Lorentz's electron radius of $1\cdot 5 \times 10^{-13}$. For a circular electronic orbit the radiation should balance the centrifugal force, and assuming this gives $h = 5\cdot 92 \times 10^{-27}$. Both values of h agree well with experiment, considering our very limited knowledge of a. This agreement, moreover, affords strong confirmation of the Equivalence Principle. G. W. DE T.

27. *Meaning of Rotation in the Special Theory of Relativity.* **P. Franklin.** (Nat. Acad. Sci., Proc. 8. pp. 265–268, Sept., 1922.)—The Newtonian equations effecting the tranformation of coordinates from a system K to another K′ rotating about the Z-axis can be regarded, in the light of the special theory of relativity, only as a first approximation applicable to points near the axis of rotation, as the velocities of points sufficiently far from the axis are greater than the velocity of light. This difficulty is obviated by employing the transformations,

$$\theta' = \theta \cosh \omega r/c - ct \sinh (\omega r/c)/r, \quad r' = r, \quad z' = z,$$
$$t' = t \cosh \omega r/c - r\theta \sinh (\omega r/c)/c,$$

which are deduced by the application of the Lorentz transformation to the case of rotation, making three assumptions. Space–time in the rotating system is non-Euclidean, the spacial geometry depending on the coordinates of the point considered. The value of the Gaussian curvature for the case $t' = 0$ is calculated, and it is shown that the curvature of the spacial cross-section at any space–time point, in coordinates "natural" to this point is the square of the angular velocity of rotation in radians per light-second. J. S. G. T.

28. *Audibility of Aurora.* **J. G. Griffin.** (Roy. Astron. Soc. Canada, J. 16. pp. 255–260, Sept.–Oct., 1922.)—The author presents some information he has collected from various authorities with reference to the faint swishing crackling sounds which have been reported by a number of observers to accompany auroral displays. Amundsen states that when once called out to hear this crackling he found it due to the rapid freezing of the moisture from the breath of the observer, and the consequent tinkle of the minute crystals falling close to his face. This explanation seems doubtful, as the sounds have not been heard when no aurora were visible; also H. D. Curtis and other observers have heard such sounds in latitudes around 50° in summer when the temperature was too high for the breath to be frozen in this manner.

During thunderstorms a very sharp click has been heard by Cooke, its occurrence being coincident with the lightning. This was always heard at Perth, W.A. Observatory, when the flash was just overhead. He suggests a connection between these noises since both thunderstorms and aurora are associated with electrical activity in the atmosphere. A. W. L.

29. *Structure of Anticyclones and Cyclones in the Upper Atmosphere over Europe.* **F. M. Exner.** (Meteorolog. Zeits. 38. pp. 296–290, Oct., 1921.)—Utilising observations of temperature and pressure in the upper air, derived from the international series of soundings, A. Schedler has given curves showing the mean distribution of temperature and pressure at various levels, and of the height of the stratosphere, along an E.-W. line through a cyclone and the adjacent anticyclones. The present paper discusses the diagram obtained by superimposing Schedler's separate curves for temperature and pressure. This brings out clearly, for example, that the marked asymmetry of temperature with respect to the centres of high or low pressures in the lower troposphere becomes less marked with increasing height, until it no longer exists in the highest layers of the troposphere and in the stratosphere, a gradual change of phase leading to symmetry at such heights. The curves are in agreement with all the well-known results (particularly with Dines's correlation coefficients) as to a low warm stratosphere over cyclones, etc. It is traced how the state of things represented may arise out of a southward flux of cold air from the north in the lower troposphere, with a compensating northward warm current, it being unnecessary to seek the origin of cyclones in the stratosphere. The intimate connection of events above with those below justify the whole being regarded as one system, in opposition to Ficker's representation of "compound depressions" into which two more or less independent systems, an upper and a lower, enter. [See Abs. 1690 (1921).] M. A. G.

30. *Diurnal Variation of Wind Velocity in the "Intermediate Layer."* **W. Köppen.** (Meteorolog. Zeits. 38. pp. 353–358, Dec., 1921.)—Discusses the complicated diurnal variation of wind velocity in the "intermediate layer," on the basis of observations made on the Eiffel Tower, high masts at two wireless stations in Germany, and other high structures. The stratum referred to is that lying between the layer next to the surface where a day max. and night min. occur and the higher layer where the reverse holds. It extends from 30 m. to 300 m. above the surface, varying with the weather and the time of year. M. A. G.

31. *Coudersport Ice Mine.* **E. S. Balch.** (Am. Phil. Soc., Proc. 60. 4. pp. 553–559, 1921.)—This "glacière" in Pennsylvania consists of a shaft 30 ft. deep, with a cross-section about 10 ft. by 8 ft., situated on the north side of a hill and completely shielded from sun and wind by thick forest. In it, ice commences to form in April and after June diminishes, vanishing in October. The note points out that the accepted explanation of "glacières" is applicable here, viz. that the cold air of winter sinks into the shaft, later freezing the water yielded by the spring thaws on the surface, this ice in turn thawing as summer advances. There is, however, this difference from the larger European "glacières," that the shaft is not large enough to contain sufficient cold air to prolong the freezing so long as is observed, a supplementary supply probably flowing in from ice-containing crevices higher up the hillside. M. A. G.

32. *The Halo of 46°.* **L. Besson.** (Monthly Weather Rev. 50. p. 310, June, 1922.)—C. S. Hastings has suggested [Abs. 2062 (1922)] that the 46° halo is produced by horizontally oriented crystals and not, as is usually supposed, by right-angled refracting edges with wholly random directions, just as the 22° halo is by 60° prisms. L. Besson opposed Hastings's theory, supporting his remarks by observations which cannot be reconciled with it. Some further notes on the 46° halo are given, including a table showing the frequency of other halo phenomena visible with it, based on 79 observations at Montsouris from 1898 to 1908. As a rule the 22° halo accompanied it alone, but on 5 % of the occasions there was no accompanying phenomenon at all. Attention is directed to the possibility of a 44° halo accompanying the 22° halo, produced "secondarily" by two successive refractions in 60° prisms. M. A. G.

33. *Meridional Temperature Distribution on the Earth and the Exchange of Air between Equator and Pole.* **A. Defant.** (Meteorolog. Zeits. 39. pp. 8–14, Jan., 1922.)—The exchange of air between equator and pole, associated with the depressions of middle latitudes, brings about a flux of heat northward represented, for averages over a long time, such as a year, by $-\sigma A\frac{ds}{dh}$, where σ is the specific heat at constant pressure and $\frac{ds}{dh}$ the N − S temperature gradient. A, the "Austauch," in this large-scale turbulent motion, is estimated at 10^8 cm.$^{-1}$ g.sec.$^{-1}$ giving, in lat. 45° N., a northward flux of heat of 100 g.cal. per cm.^{2} per min. The intensity of this turbulent motion plays a large part in determining the meridional distribution of temperature, theoretical values for which, corresponding to different values of A, are determined. The value of A taken above, viz. 10^8, derived from considerations of the dimensions of depressions, gives the best approximation to the observed mean annual temperature distribution. M. A. G.

34. *Weekly Rainfall.* **R. A. Fisher and W. A. Mackenzie.** (Roy. Meteorolog. Soc., J. 48. pp. 234–242; Disc., 242–245, July, 1922.)—The correlation of the weekly rainfalls between different places is considered, and the data for Rothamsted, York, and Aberdeen are examined with a view to establishing adequate methods and exploring the main features of weather localisation. The mean correlation, measured on the z scale, falls off with increasing distance in a regular manner. It is probable that simple laws may connect these quantities over considerable areas which will afford knowledge of the accuracy of meteorological estimates, based on a limited number of stations. A well-marked annual periodicity in the rainfall correlations exists in the data examined. The rainfall is most highly localised in July, and least so about the end of February. The correlation rises relatively slowly in the autumn, and for the longest distance examined (375 miles) the autumn values remain for about three months close to the mean value for the year. W. A. R.

35. *Rainfall and Temperature.* **W. T. Russell.** (Roy. Meteorolog. Soc., J. 48. pp. 225–230; Disc., 230–233, July, 1922.)—The correlation between rainfall and temperature is examined for the following towns: Greenwich, Glasgow, Greenock, and Dundee. The correlation between one month and the next following for temperature is not high (0·3); and the largest coefficients are obtained in the winter and summer months. The temperature correlation between the same months in successive years is insignificant. There is no definite relation between the rainfalls of successive months. There seems to be a greater connection between the rainfalls of alternate months. Thus, at Greenwich a wet June fore-

casts a wet August (coeff. 0·55). Finally the correlation between temperature and rainfall is distinct—negative in summer and positive in winter.
W. A. R.

36. *Calculation of Normal Frost Dates from Short Temperature Records.* **W. B. Van Arsdel.** (Monthly Weather Rev. 50. pp. 297–301, June, 1922.)—The frost data usually required are the dates of the first and last frost and the length of the growing season. The author describes an indirect method of determining these when data are available for only a few years and so direct averaging is impossible. The smoothed curve of normal daily minimum temperature is drawn, and from the dispersion of actual minima about the mean, the probability that the temperature will be *n* degrees above or below the mean is obtained. From this the probability of frost occurrence (P_1) can be plotted against the date. The probability that frost shall not have occurred before any given date (P_2) is the continued product of the daily probabilities that frost will not occur, i.e. the continued product of ($1 - P_1$) starting far enough back in the summer for the first terms to be approximately unity. Hence the probability of the first occurrence of frost is P_1P_2, and the curves showing the probability of first frost in autumn and last frost in spring can be constructed.
A. W. L.

37. *The Topographic Thunderstorm.* **C. Hallenbeck.** (Monthly Weather Rev. 50. pp. 284–287, June, 1922. Paper read before Am. Meteorolog. Soc., Utah, June, 1922.)—The author describes two types of topographically generated thunderstorms which occur in the Pecos Valley, New Mexico. The former is similar to that due to the underrunning of humid air by a colder current and is formed by warm humid air blowing up a long slope and so setting up condensation and convection. Thunderstorms of this type occur on summer mornings and always tend to gravitate down the slope. The air under the storm cloud is comparatively cold, and as it flows down it deflects the opposing flow of warm air; the portion deflected upwards forms the rising column in the front of the storm. These storms are of frequent occurrence, giving heavy precipitation on the higher regions, but they tend to die out on moving downwards owing to the progressive increase in the depression of the dew point.

The second type occur at night above a sheet of low cloud; they always move up the valley, and several of these storms often arise in succession. The surface wind shows no material change in direction or velocity. It is suggested that the dew point varies slightly throughout the valley, and consequently condensation occurs at several points as the humid air blows up the slope. This would give rise to a series of convections which eventually link up to form the cloud sheet, but above the cloud they again separate, giving rise to a series of storms. Storms of this type are infrequent and give heavy precipitation.
A. W. L.

38. *Seiches.* **E. M. Wedderburn.** (Roy. Meteorolog. Soc., J. 48. pp. 211–223, July, 1922.)—The paper is the report of a lecture which summarises research on seiches (with a bibliography) up to date. The most important causes seem to be the progression of a system of isobars over the lake surface, and the formation of a layer of warm, light water in the spring and summer, giving rise to the "temperature seiche."
W. A. R.

39. *Surface Temperatures in the North Sea and in German Lakes.* (Nature, 110. p. 229, Aug. 12, 1922.)—The International Council for Marine Investigations (Bull. Hydrographique, June, 1922) summarises the observations of surface temperature in the North Sea from 1905–1914. Expressed graphically, these show in a striking manner the "flow" of the isothermal boundaries throughout the year. Temperatures in the German lakes are dealt with by A. Merz (Veröffentlich. Inst. f. Meereskunde, 5, 1920). A special thermometer was used. On calm days, when there is no vertical disturbance of the water, the temperatures may vary from 21° C. at the surface, to about 8° C. at a depth of 100 mm. W. A. R.

40. *Contributions to the Cosmologic Problem.* **F. Selety.** (Ann. d. Physik, 68. 4. pp. 281–334, Aug. 17, 1922.)—Part I.—(*a*) Compatibility of suppositions 1–4 with each other and with Newton's law. (*b*) Einstein's objections to the star cluster world. Possibility of such a world with infinite mass in statistical equilibrium. (*c*) The molecular hierarchical world. (*d*) Possibility of its having no centre. Pt. II.—(*a*) Determination of inertia through matter. (*b*) Determination of the systems of inertia in the molecular hierarchical world. (*c*) No distinction of a definite system among them.

The first part of this paper attempts to demonstrate the compatibility and physical admissibility of the following assumptions generally looked upon as incompatible: (1) Infinite extension of the world in space. (2) Infinity of its mass. (3) Complete filling of space with matter of finite local density. (4) Disappearance of the world's mean density. (5) Non-existence of a single central point or central area of the world. The object of the second part is to demonstrate the possibility of finding a satisfactory solution of the problem of the determination of inertia, or of the system of inertia through matter with a distribution of matter fulfilling the above suppositions. E. F.

41. *Mean Areas and Heliographic Latitudes of Sun-Spots in the Year 1918.* (Roy. Astron. Soc., M.N. 82. pp. 483–486, June, 1922.)—This is one of the regular series of annual results obtained at Greenwich from a practically complete set of solar photographs taken generally either at Greenwich or the Cape, some otherwise missing dates being supplied from India, either from Dehra Dûn or Kodaikanal. The daily area for 1918 shows a marked decrease from 1917, the northern hemisphere showing more activity than the southern. The latitude of spots shows the usual progressive diminution. No day was free from spots. W. W. B.

42. *Method of Stellar Photographic Photometry without Screens or Gratings.* **J. Halm.** (Roy. Astron. Soc., M.N. 82. pp. 472–478, June, 1922.)—By varying the time of exposure on a single field a relation is obtained between the diameters of images and the time of exposure. Another relation is found between images of stars of different magnitudes. From these a curve is derived which will measure photographic magnitudes if independent determinations are available for any of the stars. A test comparison of the Pleiades with determinations by Hertzsprung and at Mount Wilson shows satisfactory agreement. The method is more strictly available for faint stars than bright ones. W. W. B.

LIGHT.

43. *Measurement of Light.* **N. Campbell** and **B. P. Dudding.** (Phil. Mag. 44. pp. 577–590, Sept., 1922.)—The authors consider that in order to establish a scientifically or legally satisfactory system of measuring any physical magnitude it is not sufficient to define the units, but it is necessary also to state the laws of measurement involved. They illustrate this contention by reference to photometric measurement, taking illumination as the fundamental photometric magnitude. They define "photometric surfaces" as members of pairs, each pair being such that if their positions are interchanged while everything else remains unaltered, equality of brightness is undisturbed whatever the nature of the illumination. Illumination is characteristic, not of the surface illuminated, but of the circumstances in which that surface is placed, and experiment shows that illumination is subject to (*a*) the law of addition (excluding the Purkinje region), (*b*) the inverse square law, and (*c*) the cosine law. From (*b*) follows the definition of luminous intensity ($\Phi \propto Ir^2$) in a given direction and the flux $F \propto \int \Phi d\omega$ where ω = solid angle. Brightness B follows as luminous intensity per unit projected area. The constants of the above relationships are taken as unity.
J. W. T. W.

44. *Absorption of Light by Sodium and Potassium Vapours.* **G. R. Harrison.** (Nat. Acad. Sci., Proc. 8. pp. 260–263, Aug., 1922.)—A preliminary account is given of an investigation of the relation of the band, line, and continuous absorption in sodium and potassium vapours to temperature, hydrogen pressure, and vapour saturation. *Sodium.*—The continuous absorption was found to be much more pronounced in some cases than in others, but the only determining factor appears to be vapour density. Hydrogen pressures up to 400 mm. had no visible effect. All photographs showed that the continuous absorption decreased rapidly with decreasing wave-length. Curves are given showing transmission of light as ordinates and wave-lengths as abscissæ; these illustrate how the absorption changes with vapour density. *Potassium.*—This metal showed similar continuous absorption to that of sodium. Corresponding curves are given for transmission and wave-length. A. W.

45. *Refraction in Circular Cylinders or Spheres.* **C. Schmidt.** (Phys. Zeits. 23. pp. 310–311, Aug. 1, 1922.)—The author gives a simple theoretical treatment of the refraction of light through a circular cylinder or sphere. Formulæ are obtained by which the refractive index of the material may be obtained from simple measurements. A. W.

46. *Absorption of Ultra-Violet Radiation by the Eye.* **W. P. Graham.** (Optical Soc. America, J. 6. pp. 605–614, Aug., 1922.)—Previous researches are briefly summarised. Detection of fluorescence is not a complete test. The author describes arrangements for illuminating a slit of specified shape with ultra-violet light in order to ascertain if an image is formed on the retina. The following conclusions are drawn from his experiments: (1) The combined tissues of the eye absorb ultra-violet radiations up to 0·3134 μ; (2) the lens has the largest region of absorption; (3) formalin changes the absorption, and (4) an injury or disease tending to increase the salt content in the eye radically changes the absorption. It appears that absorption in animals' eyes does not differ radically from that in the human. J. S. D.

47. *Diffraction Haloes in Normal and Glaucomatous Eyes.* **H. H. Emsley** and **E. F. Fincham.** (Optical Soc., Trans. 23. pp. 225–236; Disc., 236–240, 1921–1922.)—Attempts have been made to distinguish between the haloes seen round a small bright source of light, in a dark room, by normal and by glaucomatous eyes, by measuring the angles subtended by the haloes seen. Most observers agree that the angular diameter of the yellow-green portion for normal eyes is 6° or 7°. In glaucoma the size varies greatly, being as low as 3° in some cases, and as high as 16° in others. Some patients see haloes of about the same diameter as persons with normal eyes, so that the size of halo is not an infallible guide for diagnosis. When an opaque screen with a vertical straight edge is moved horizontally before a normal eye the portions of the halo on and about the horizontal diameter disappear, leaving only the top and bottom portions, when the forward edge of the screen reaches a position a little beyond the centre of the pupil; the obliterated portions increase in angle, and the bright portions diminish, as the screen moves on to cover the whole of the pupil. When a vertical slit is used in the same way the appearance, when the slit passes the edge of the pupil, is the same as when the screen described above has nearly covered the pupil, two spectra being seen at the ends of a vertical diameter; as the slit moves on these spectra break each into two, so that the halo has four breaks, two at the ends of the vertical and two at the ends of the horizontal diameter, with four bright portions between; the distance between these at the top and bottom increases, while that right and left diminishes as the slit moves on, until, when the centre of the slit is at the centre of the pupil, the four spectra have united into two at the ends of the horizontal diameter; further movement gives four spectra again, which unite into two at the ends of the vertical diameter just before the slit passes beyond the opening of the pupil. These are the phenomena seen under suitable conditions with normal eyes, the impression being that two diameters *bb'* and *cc'*, with spectra at their ends, rotate, one clockwise and the other anti-clockwise. Some eyes see the spectra which rotate clockwise more distinctly and some the pair which rotate anti-clockwise, the two eyes of the same observer sometimes differing in this respect. The phenomena are shown to be due to the radial fibrous structure of the outer edge of the crystalline lens. This forms a radial grating, which produces the halo, and when parts of it are covered up gaps appear in the circular halo, as described above. In glaucoma, when an opaque screen is passed in front of the eye, the ring of the halo simply decreases in brilliancy, and all parts of it finally disappear simultaneously; the phenomena described above for the slit are not observed; the halo behaves as though it were due to œdematous globules in the tissues of the cornea, due to the increased intra-ocular tension, giving the same effect as is produced by a glass plate dusted with lycopodium powder. In the *discussion*, in which the value of the results for use in diagnosis was fully recognised, **E. E. Maddox** suggested that glaucomatous haloes are due to subepithelial sweating of the cornea, raising the epithelium into multitudes of tiny hillocks, or to stretching of the cornea, which might contribute by dislocating the fibres from their optical packing; since they run in all directions the phenomena produced by a screen passing across the cornea would differ entirely from the lenticular ones, and resemble those of glaucoma. **H. N. A.**

48. *Heteromorphies due to Variation of Effective Aperture and Visual Acuity.* **K. Horovitz.** (Optical Soc. America, J. 6. pp. 597–604, Aug., 1922.) —In some cases where optical instruments produce a perfect image apparent alterations of space are perceptible. These effects are termed "heteromorphies." They may be observed by persons with normal vision, and may thus be independent of the dioptric system, but the effective aperture of the pupil may influence the image in various ways. Acuteness of vision is diminished by a reduction of the intensity of illumination, by flooding the retina with useless light, by the darkening of simultaneous contrasts, and, of course, by wrong adjustment. Experiments on persons whose pupil had lost the reaction to light showed that reduction of acuteness of vision is always followed by apparent diminution in size and the bringing nearer together of objects observed. The optical transformation of the object-space into the visual-space is defined by simple postulates of invariance and is proved to be a relief-perspective. Heteromorphies may be constructed as a virtual shifting forward of the point of view. J. S. D.

49. *Report of Committee on Colorimetry.* **L. T. Troland.** (Optical Soc. America J. 6. pp. 527–596, Aug., 1922.)—The report is mainly concerned with (1) the clarification and standardisation of colour terminology, (2) the compilation of fundamental data relating to colour, (3) the specification of standard stimuli and conditions for use in research on colour. The section on nomenclature contains, first, a discussion of such terms as colour, brilliance, hue, and saturation. Next, "stimulus terms" (radiant energy, spectral distribution, purity, etc.) are dealt with. Thirdly, psychophysical functions, and such conceptions as luminosity, visibility, and complementary colours are treated. The section on data includes a spectral chroma scale, diagrams illustrating the violet, green and red excitations, and a diagram summarising observations from different sources on complementary colours. A series of graphs illustrate the Planckian energy distribution at various temperatures. In dealing with physical standards the committee presents a curve illustrating the distribution of intensity in the spectrum for average noon sunlight, which is compared with the proposed standard of "artificial daylight" due to Priest, based on the radiation from a gas-filled lamp operating at 2848° K. (approximate equivalent to 15·6 lumens per watt), transmitted through crossed nicols and a crystalline quartz plate 0·5 mm. thick. A table of colour-temperatures of common illuminants is also included. Standard three-colour filters are briefly treated, and finally there is a discussion of various systems of defining colours (Munsell, Ridgway, and Ostwald) and a summary of available methods of colorimetry. At the end of the report is a bibliography of papers on colour. J. S. D.

50. *New Principle in Contrast Photometry.* **E. P. Hyde** and **F. E. Cady.** (Optical Soc. America, J. 6. pp. 615–619, Aug., 1922.)—The authors describe a form of Lummer-Brodhun photometer head in which the degree of contrast is varied, increasing from the bottom upwards in one trapezoid, while it increases from the top downwards in the other. The gradation of contrast is obtained by removing the separate glass plates giving the 8 per cent. contrast in the ordinary Lummer-Brodhun field, and substituting for them a thin sheet of glass sufficiently large to cover the whole side of the cube, and having cemented to it on one side a thin piece of neutral glass having a gradually varying transmission ratio. It is pointed out by the authors that this method of introducing the contrast makes it easy to obtain the optimum value of contrast, which Lummer and Brodhun found to be about 3½ per cent., instead of the usual value of 8 per cent. which was found to be only about half as sensitive. The device described has not yet been fully tried in practice. J. W. T. W.

51. *Ionisation of Potassium Vapour by Light.* **R. C. Williamson.** (Nat. Acad. Sci., Proc. 8. pp. 255–260, Aug., 1922.)—Experiments are described which give evidence that potassium vapour may be ionised by light. The results indicate that there is a long-wave limit in the case of this ionisation, which can be calculated from the relation $Ve = h\nu$ by means of the ionising potential. The ionising power of the radiation is a continuous function of the wave-length below this limit, increasing as the wave-length decreases. A. W.

52. *Emission Spectrum of Monatomic Iodine Vapour.* **St. Landau-Ziemecki.** (Phil. Mag. 44. pp. 651–656, Sept., 1922.)—In the experiments here described a quartz tube with a large central portion (12 cm. long and 1 cm. diam.) and external electrodes was employed. Special precautions were taken to purify the iodine before introducing it into the tube. The tube was heated in an electric oven and viewed end-on. When not heated the tube gave the ordinary band spectrum, but on raising the temperature to about 1000° C., the conditions of excitation remaining the same, a new line spectrum replaced the band spectrum. The new spectrum is quite different from that obtained with narrow tubes and condensed discharges. It consists of relatively few lines. Two lines in the ultra-violet, λλ3384, 3281, are especially strong and characteristic; the others are faint. The approximate wave-lengths of 21 lines lying between λ4868 and λ2507 are given. Further experiments with another discharge tube showed the band spectrum to have a very regular structure, short exposures revealing the presence of many well-defined maxima. The new line spectrum probably belongs to the atom of iodine. It appears more and more strongly with increase of the dissociation of the iodine molecules as the temperature is raised; the band spectrum at the same time becomes fainter and finally disappears. The band spectrum thus appears to belong to the iodine molecule. A. W.

53. *Atomic Hydrogen and the Balmer Series Spectrum.* **R. W. Wood.** (Phil. Mag. 44. pp. 538–546, Sept., 1922.)—The present paper gives an explanation of practically all the curious spectroscopic phenomena observed with very long vacuum tubes containing hydrogen, and described in previous papers [Abs. 546 (1922)]. (1) *Atomic Hydrogen.*—The secondary spectrum of hydrogen is most probably emitted by the hydrogen molecules; the Balmer series lines by the atoms. With a heavy current in the tube, the dissociation into atoms is nearly complete and permanent, no appreciable recombination occurring during the very brief current pauses which occur when the transformer potentials are near the zero value. At the ends of the tube, molecular hydrogen is continuously supplied by the bulbs, the metallic electrodes acting as catalysers causing the instantaneous recombination of the dissociated hydrogen. With a feeble current, atomic hydrogen is not formed rapidly enough to permit of high concentrations, and this explains the feeble character of the Balmer lines with weak currents. In view of the results of certain experiments it appears as if the glass wall of the tube, when thoroughly freed from adsorbed water vapour or oxygen, acts as a powerful catalyser of atomic hydrogen, so that in dry hydrogen the concentration of atomic hydrogen never reaches a value high enough to cause the Balmer spectrum to appear. It appears extremely probable that the part played by water vapour in bringing out the Balmer series is merely that of supplying a "poison" (oxygen) for the catalysing wall of the tube, thus permitting a high concentration of atomic hydrogen under the action of a heavy discharge. It has been found possible to pump off atomic hydrogen from a tube operated by a heavy current, and to study its chemical and physical properties. Wires of certain metals, and certain oxides, when introduced into the stream of atomic hydrogen, come spontaneously to incandescence and cause the formation of molecular hydrogen. Tubes of pyrex glass have been found better than soft glass tubes, but quartz does not appear to be any better than pyrex glass. (2) *Balmer Series.*—The lines of the Balmer series were photographed in the 2nd and 3rd order spectrum of a very perfect 7-inch plane grating with an objective of 20 ft. focus, H_α, H_β, and H_γ all showing as clearly separated doublets. With a 12 hours' exposure the series was recorded down to the 18th line. With a specially selected plane grating and using a coloured screen to cut out the overlapping green of the 3rd order and violet of the 5th order, photographs in the 5th order were obtained of the end lines of the Balmer series. Using the new tubes of pyrex glass the 20th line was photographed with certainty, and probably the 22nd. The 21st is so nearly in coincidence with a strong line of the secondary spectrum that it cannot be indentified under present conditions. The wave-lengths of the lines from the 3rd to the 20th have been measured accurately, a table being here given. Two series of measurements on the components of H_γ gave a value $0\cdot0584$ I.Å. for the doublet separation, which is in exact agreement with the value obtained by Gehrcke and Lau. A. W.

54. *Curvature of Lines in Prismatic Spectrum.* **H. C. Plummer.** (Roy. Astron. Soc., M.N. 82, pp. 466–472, June, 1922.)—This is a rediscussion of the property of a prism by which the image of a straight slit becomes curved, a former proof by Ditscheiner in 1865 being not readily accessible. The property may be neutralised by using a suitably curved slit, but this is not applicable to solar work. The conclusion reached is that the curvature cannot be eliminated entirely, but can be mitigated by using lenses of long focal length. It appears also that the position of minimum curvature is also that of minimum dispersion. W. W. B.

55. *Optical Demonstration of Bragg's Method of Crystal Analysis.* **B. Quarder.** (Phys. Zeits. 23. pp. 350–352, Sept. 1, 1922.)—The author suggests, from the X-ray analogy, a method of producing photographic plates which possess similar reflection properties with regard to light that crystals have with regard to X-rays; that is, the light is reflected from successive layers in the same manner that the X-rays are reflected from successive layers of atoms in a crystal. Thus values of grating constant g from 77 μ to 131 μ have been employed using photomechanical plates. A. B. W.

56. *Assumptions in the Quantum-Orbit Theory of Spectra.* **W. M. Hicks.** (Phil. Mag. 44. pp. 346–351, Aug., 1922.)—This paper gives a critical study of certain assumptions made by Sommerfeld in "Atombau und Spektrallinien." The original paper should be consulted by those interested. A. W.

57. *A New X-Ray Diffraction Apparatus.* **W. P. Davey.** (Gen. El. Rev. 25. pp. 565–580, Sept., 1922.)—A description is given of an apparatus by means of which the characteristic X-ray diffraction patterns of 15 powdered crystals may be taken at once. Each pattern is recorded on a strip of photographic film placed in a cassette, which automatically holds the film on the arc of a circle of 8-inch radius, having at its centre the specimen of powdered crystal. The time required to obtain a satisfactory record of the diffraction pattern varies from 5 to 12 hours for substances like NaCl to 70 hours for substances like CuCl and CsI. The diffraction pattern may be interpreted directly in terms of the interplanar distances in the crystal by means of a metal scale, which is calibrated in Ångstrom units. If the crystal belongs to the cubic, tetragonal, or hexagonal systems, its structure may be interpreted directly from these interplanar distances by means of prepared charts, a number of which are included in the paper. The apparatus has been developed to provide a convenient means of applying the X-ray method of analysis to general crystal research and factory-control work. E. A. O.

RADIO-ACTIVITY.

58. *Attempt to Influence Rate of Radio-active Disintegration by the Use of Penetrating Radiation.* **G. v. Hevesy.** (Nature, 110. p. 216, Aug. 12, 1922.)—Investigations by Ellis [Abs. 1638 (1922)] lead to the conclusion that quantum dynamics probably apply to the nucleus of the atom and lend support to the assumption that the emission of γ-rays from the nucleus precedes the disintegration process. This hypothesis suggested an investigation as to whether or not the rate of radio-active disintegration can be influenced by exposing the substance to the action of penetrating radiation. Could the nucleus be induced to take up a γ-ray impulse supplied by an exterior source, it would mean a change in its stability and so most probably in the rate of its disintegration. As γ-ray source about 800 mg. of radium element were used, and experiments carried out with uranium UX, and RaD in equilibrium with RaE no certain change could in any case be detected. A. B. W.

59. *Rise of γ-Activity of Radium Emanation.* **F. P. Slater.** (Phil. Mag. 44. pp. 300–304, Aug., 1922.)—Curves showing the rise of γ-ray activity from pure radium emanation measured through a wide range of absorption thickness of matter have been determined and utilised in deducing the absorption coefficients of the heterogeneous γ-radiation from radium B. A. B. W.

HEAT.

60. *The Thermal Stresses in Solid and in Hollow Circular Cylinders Concentrically Heated.* **C. H. Lees.** (Roy. Soc., Proc. 101. pp. 411–430, Aug. 1, 1922.)—Abs. 937 (1922) gives a similar investigation for spherical bodies. In the case of the heating or firing tunnel used in pottery and other works, and of the pillars supporting the floors of a building in which a fire occurs, the thermal stresses may exceed the breaking strength of the materials, causing them to be crushed or torn asunder. The calculation of these stresses for a hollow cylinder of constant elasticity and heat conductivity has been made by Lorenz [see Abs. 1120 (1907)], but only on the assumption of a steady logarithmic law for the temperature distribution, and a linear law for the expansion. In the present paper the problem is treated in a more general way. It is shown that for any temperature distribution, with any law of expansion, the stresses may be found by a simple graphical method, so long as the variation of the elastic constants with temperature may be neglected.

Measurements of length on a simply constructed diagram, together with a knowledge of Young's modulus, Poisson's ratio, and the curve of dilatation for the material, enable one to calculate the mechanical stresses, R, T, and X (radial, tangential, and axial), the mean pressure $\frac{1}{3}(R+T+X)$, and the shear stresses $\frac{1}{2}(X-T)$, $\frac{1}{2}(R-T)$, and $\frac{1}{2}(R-X)$. The numerical evaluation of stresses in some practical cases, (1) a long pottery kiln or furnace, (2) a concrete or masonry pillar subjected to fire, is considered. Experimental evidence by W. A. Hull and others appears to support the theoretical conclusions of the paper. T. B.

61. *A Recording and Integrating Gas Calorimeter.* **J. S. G. Thomas.** (Nature, 110. pp. 251–253, Aug. 19, 1922.)—The article is a brief description, with illustrations, of C. V. Boys' calorimeter, described by him at the annual meeting of the Institution of Gas Engineers on June 22nd. The calorimeter is of the water-flow type, the same water being circulated continuously through the apparatus. The fundamental features of the instrument are: water and gas are doled out positively at the correct respective rates, and the correction for gas volume as affected by temperature, pressure, and humidity, are likewise effected by a positive operation. A number of extremely ingenious features are embodied in the design, but it is impossible to form a clear idea of the instrument without the aid of several diagrams. E. G.

62. *The Specific Heat of Superheated Steam for Pressures from* 20 *to* 30 *Atmospheres, and for Temperatures of Saturation up to* 350° *C.* **O. Knoblauch** and **E. Raisch.** (Zeits. Vereines deutsch. Ing. 66. pp. 418–423, April 29, 1922.)—This is a continuation of work started before the European War, in consequence of which the publication has been delayed. Previous work at the Laboratory for Technical Physics at Munich had covered a range of 0·5 to 20 atmos., and the present work extends it to 30 atmos. The results are in agreement with the conclusions previously deduced, i.e. that the values of C_p at a given temperature increase with increasing pressure, and at a given pressure decrease with increasing temperature.

The paper gives a full account, with diagrams of the apparatus used, of the method of conducting the investigations. The necessary precautions to be taken in jacketing the parts of the apparatus to prevent heat loss and to obtain dry steam are fully described.

Briefly, the method used is as follows :—Steam from a large boiler is passed through a vertical heater in order to dry it, and then into the calorimeter. From the calorimeter it flows to a condenser, from which the condensed water is drawn off and weighed. The difference in pressure of the steam at entrance and emergence from the calorimeter is given by a specially constructed manometer, and the temperature difference by two standard mercury thermometers reading to 0·5° C. The calculated values of C_p are tabulated and curves are drawn between C_p and the temperature for each pressure employed. Electrical heating was used and 12 heating circuits with 26 thermo-couples were employed to prevent appreciable loss by radiation from the several parts of the apparatus. The observed quantities had the following approximate values :—Heat given to calorimeter, 650 watts ; Heat lost from calorimeter, 44 watts ; Weight of steam condensed per hour, 62 kgs. ; Superheating 3·5° to 17° C. T. B.

63. *Latent Heats of Vaporisation and Expansion.* **D. L. Hammick.** (Phil. Mag. 44. pp. 590–594, Sept., 1922.)—According to van der Waals, the pressure in a homogeneous fluid system is $p + a/v^2$. Thus the work of expanding 1 grm. of liquid, of vol. v_1 c.c. to v_2 c.c., the specific volume when completely vaporised, is $A = \int_{v_1}^{v_2} (p + a/v^2)dv$, giving, for v_2 large compared to v_1, and putting pv_2 equal approximately to RT/M, $A = RT/M - a/v_1$. Then if

$$T(dA/dT)_v = A - U, \quad - U = a/v_1 \,.\, (1 - TdA/adT) = \lambda_{ex.},$$

the latent heat of the expansion. Now H. Davies has shown [Abs. 1915 (1912)] that the initial pressure π in a fluid is $4R/v_c \,.\, (2T_c - T)$ and that α, the coefficient of cubical expansion is $1/(2T_c - T)$. Hence $\pi^{-1}(d\pi/dT)_v = - \alpha$, and if $\pi = a/v^2$, $\lambda_{ex.} = a/v \,.\, (1 + \alpha T)$, which becomes a/v_0 for $T = 0$, and so at absolute zero becomes identical with Bakker's expression for the latent heat of vaporisation. The two latent heats would be equal if there were no change in the internal energy during transition, at constant volume, from the liquid to the vapour phase, i.e. the condition for equality is $\int_0^T C_v dT - \int_0^T c_v dT = 0$, C_v and c_v, being the respective specific heats at constant volume. Otherwise, the difference between $\lambda_{vap.}$ and $\lambda_{ex.}$ will be $\int_0^T (C_v - c_v)dT = H$, say. If a change in molecular aggregation occurs during transition, a further quantity of heat, h, representing heat of association, must be considered, and then $\lambda_{vap.} = \lambda_{ex.} + H + h$. An accompanying table shows that for the 35 elements and compounds tabulated, the values of $\lambda_{ex.}$ calculated at the boiling-point agree well with the observed values of $\lambda_{vap.}$, so that, at the boiling-point, $H + h = 0$. But $h = 0$ for "normal," or unassociated liquids, so that $H = \int_0^T (C_v - c_v)dT = 0$. At the end of the table are given some results for liquids generally regarded as associated. For water $H + h = 0$, approximately, so that H and h must be nearly equal but opposite in sign. G. W. de T.

64. *A Simple Apparatus for Comparing the Thermal Conductivity of Metals and very Thin Specimens of Poor Conductors.* **M. S. Van Dusen.** (Optical Soc. America, J. 6. pp. 739–743, Sept., 1922.)—Description of apparatus used for measuring the thermal resistance of various contacts between metals, either with or without the addition of some cementing material, and for comparing the thermal conductivity of metals and thin specimens of poor conductors. The method consists essentially in comparing the temperature gradients in two materials placed in series, the rate of heat flow in each being the same. The temperatures are measured by means of thermoelements of copper constantan. E. G.

65. *Partition of Energy.* **C. G. Darwin** and **R. H. Fowler.** (Phil. Mag. 44. pp. 450–479, Sept., 1922.)—The authors here develop a method of calculating partitions of energy in which the determination of the most probable state is replaced by the direct calculation of the average state, which is the quantity actually required. The new procedure obviates the use of Stirling's approximation for factorials, and further, the use of Boltzmann's theorem relating energy to probability when it is required to find the relation of the partition to the temperature rather than to the total energy. And the application of each theorem in most cases requires special, and often troublesome, justification, for it determines the average state, with rigour if desired, by use of the multinomial theorem and the theorem $1/2\pi i . \int_\gamma z^r dz = 0$ where r is any integer other than -1, while $1/2\pi i . \int_\gamma dz/z = 1$. The authors confine their attention to this determination—the second, statistical, stage of the problem and do not enter into the full discussion of the fundamental questions which arise in connection with the prior stage—the determination of what states should be taken as equally probable, and merely recall that for assemblies obeying the laws of classical mechanics Liouville's theorem shows that the elements of equal probability may be taken to be equal elements of volume in Gibbs' *phase space*. Hence, *e.g.*, in an assembly of identical systems, these elements simplify to 6-dimensional cells $\Sigma dq_i dp_j (i, j. = 1, 2, 3)$, where $q_i p_i$ are the coordinates and momenta of a single system, or the *weight* of every equal element $\Sigma dq_i dp_j$ is the same. The word *weight* here has the same sense as *a priori probability*. A basis for assigning a *weight* for each quantised state of a system is provided by Ehrenfest's adiabatic hypothesis [Abs. 403 (1917)] and Bohr's correspondence principle (The Quantum Theory of Line Spectra, Dan. Acad. 4. p. 1, 1918). It is found that an equal weight must be assigned to every permissible state in each quantised degree of freedom; otherwise the Correspondence Principle would not give consistency with classical mechanics. The authors take the quantised weights as unity and the weight of the element in the phase space as $dqdp/h$—the reverse of the usual convention—as it simplifies arguments about entropy. In *degenerate systems*, with two degrees of freedom having the same or commensurable frequencies, there is only one quantum number, and Bohr shows [loc. cit. p. 26] that the number of permissible states possessing the same total quantum number will give the weight of the state, with a corresponding rule for degeneracy in three or more degrees of freedom. The authors start with two simple examples, the distribution of molecules in space and of energy among a set of similar Planck vibrators, using elementary algebra only. Next they deal with two groups of interacting Planck vibrators of different types. It is shown that the partition can be found by evaluating the coefficient of a certain power of Z in an expression which is the product of power series in Z. This coefficient is expressible as a contour integral from which simple approximations are obtained by the *method of steepest descents.* It is a very powerful method, applicable in very many cases without difficulty; and it is comparatively easy to use it with mathematical rigour if desired, thus avoiding the somewhat clumsy calculations in the usual proofs of particular theorems. The result expresses itself naturally in terms of a parameter ϑ which is identified with temperature measured on a scale given by $\vartheta = e^{-1/kT}$. The method is then extended first to general quantised systems, then to assemblies composed partly of free molecules and partly of quantised systems. Finally the authors deal with extensions possible when molecules only are present, the most notable being a wonderfully simple proof of Maxwell's distribution law, which, the author's observe, is probably the simplest complete proof of the law, and it has the special advantage that by means of the fluctuations it is easily established that the actual distribution will hardly even be far from the average. It is pointed out that the method may be extended to cases in which the total momentum or angular momentum is conserved, by constructing partition functions in more than one independent variable. A further paper is promised dealing with the relation of the partition question to thermodynamic principles, as the increased light thrown on the statistical nature of entropy raises many interesting points which require rather careful discussion. G. W. DE T.

66. *Correlation of Entropy and Probability.* **G. A. Linhart.** (Am. Chem. Soc., J. 44. pp. 1881–1886, Sept., 1922.)—In a previous article [see Abs. 1662 (1922)] two equations are given, one connecting entropy and probability, and the other specific heats and temperature, viz. $S = \frac{C_\infty}{K} \log \frac{C_\infty}{C_\infty - C}$, and $C = \frac{C_\infty kT^k}{kT^k + 1}$. For the first of these equations ample substantiation has been found by a comparison of the calculated entropies for 18 substances with the values obtained for the same substances by a graphical method. The second equation, however, was supported by only one set of calculated values, viz. those for the specific heats of copper. The purpose of the present paper is to show that this equation, which is based upon the laws of entropy and probability, holds for the specific heats of all substances thus far obtained by thermoelectric methods. It was found that in all cases where check values are to hand the deviations from the values calculated from the equation were far less than the variations among the experimental values themselves. The author shows finally how values for S_p can in every case be found by the aid of the equations from the results obtained. Tables of data are given for sodium, silver, magnesium, calcium, cadmium, mercury, zinc, aluminium, diamond, graphite, tin (white), tin (grey), lead, sulphur (rhombic and monoclinic), iodine, the chlorides of sodium, potassium, silver, thallium, lead and mercury, the tetrachlorides of titanium, carbon, silicon and tin, formic acid, and urea. H. H. Ho.

SOUND.

67. *Doubly Resonated Hot-Wire Microphones.* **E. T. Paris.** (Roy. Soc., Proc. 101. pp. 391–410, Aug. 1, 1922.)—A continuation of work by Tucker and Paris [see Abs. 1291 (1921)]. By placing the hot wire in a short neck connecting two resonators, the range of response and sensitivity of the apparatus is increased. Two forms of double resonator are investigated; the Boys resonator consists of a "stopped pipe" connected to a Helmholtz resonator through the short neck of the latter. The outer resonator was of earthenware, 120 cms. long and 15 cms. diam.; the Helmholtz resonator was made from brass tubing 5·4 cms. diam., and was closed by a wooden piston, which was used for varying its fundamental tone. The double resonator gave maximum resonance to two tones which differed from the fundamentals of the separate resonators, and which had frequencies one higher than that of the resonator of higher pitch and one lower than that of the other resonator. The frequencies of the two resonant tones are calculated, the method of investigation following Rayleigh's treatment; and good agreement is obtained with the frequencies as measured by experiment. The observations were made in the open air; the double resonator was placed vertically, mouth downwards and about a foot from the ground. The source of sound was a Seebeck siren at 2 metres' distance, worked by a motor and a gas compressor. The microphone grid, placed in the neck between the two resonators, carried a current of 28 milliamperes, and had a "hot" resistance of 350 ohms. The grid formed one arm of a Wheatstone bridge, the balance of which was disturbed when resonance took place, and the deflection of a galvanometer measured the degree of resonance attained. The resonance (deflection, frequency) curves are shown; each curve has two maxima of deflection, the positions and amplitudes of which depend on the fundamental frequencies.

The second type of resonator consisted of two resonators of the Helmholtz pattern. This was investigated in a similar manner to the first type, and theory was found again to agree with experiment. The analogous electrical circuit and equation are given. The form of the resonance curves depends on the coupling and damping of the component resonators. Discussing the causes of sensitivity, it is indicated that a doubly resonated microphone of the type described may be more than a hundred times as sensitive, to one of its resonant tones, as a suitably tuned singly resonated microphone with an aperture similar to that of the inner resonator; this is in accordance with experience. Rayleigh had pointed out that for greater sensitivity the inner resonator must be small compared with the outer one. Up to a certain point, greater sensitivity is also effected by reducing the sectional area of the connecting neck. G. E. A.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROMAGNETICS, AND ATMOSPHERIC ELECTRICITY.

68. *Discrepancy between Electrodynamic Relativist Theories of Electromagnetic Mass.* **E. Fermi.** (Phys. Zeits. 23. pp. 340–344, Sept. 1, 1922.) —The author's objective is the locating of the cause of the discrepancy between the values U/c^2, given by relatavist theory, and $4/3 \,.\, U/c^2$, obtained by general electrodynamic methods, as the electromagnetic mass of a spherical distribution of electricity of electrostatic energy U, c being the velocity of light. His analysis is based on Hamilton's Principle, and he finds that there are two alternative methods of effecting the variation, one only of which is in accordance with relativistic theory. The application of this gives the value U/c^2; the other method gives the value $4/3 \,.\, U/c^2$. G. W. DE T.

69. *Tubes of Electromagnetic Force.* **S. R. Milner.** (Phil. Mag. 44. pp. 705–720, Oct., 1922.)—The author's primary aim is to enable a mental picture of the position and direction in hyperspace of Whittaker's "Calamoids" [Abs. 1352 (1922)] to be formed. It also extends Whittaker's results in certain respects. In a three-dimensional electrostatic field the course of a line of force can be traced from a given point by first orienting the axes so that x is in the direction of the force at the point, and then continually rotating the axes, so that this remains true at all points of the curved line to which the x-axis thus remains tangential. The properties of the tubes can then be expressed in terms of the curvatures of the lines, i.e. of the series of infinitesimal rotations. But in the electromagnetic field the directions of $\mathbf{E}$ and $\mathbf{H}$ are in general neither along the same line nor mutually perpendicular. But if $e_z = h_z = e_x e_y + h_x h_y = 0$, z will be perpendicular to the plane in which $\mathbf{e}$ and $\mathbf{h}$ lie at the point, while x and y lie in it. Now consider the field as a four-dimensional entity, and the time axis will be perpendicular to the hyperplane, or instantaneous space in which x, y, z lie. Take, with Minkowski, $c = 1$, $l = it$, since taking time imaginary substitutes a Euclidean hyperspace for the difficult hyperbolic geometry associated with real t. Then $\mathbf{e}$ and $\mathbf{h}$ obey, where there is no charge, the formal equivalent of Maxwell's equations. To an observer, the hyperplane x, y, z, for which $\mathbf{e}$ and $\mathbf{h}$ are specified must be regarded as arbitrary, and the l-axis perpendicular to it as an arbitrary direction. If the observer of $\mathbf{e}$ and $\mathbf{h}$ at the point is moving relatively thereto with speed v along the z-axis, the observed constitution of the field changes, in accordance with the Lorentz transformation, equivalent to rotating the whole set of axes in the plane of zl through an angle θ given by $\tan \theta = iv$; and starting from an arbitrary hyperplane and with axes x, y, z at a given point as origin and oriented as above, the new values $\mathbf{E}$ and $\mathbf{H}$ are found to be related to $\mathbf{e}$ and $\mathbf{h}$ by the equations $\mathbf{E}^2 - \mathbf{H}^2 = \mathbf{e}^2 - \mathbf{h}^2$, $\mathbf{EH} = (\mathbf{eh})$; whence $\mathbf{E}$ and $\mathbf{H}$ are invariants. Hence the field at the point has been simplified by the orientation of the axes into a combined electric and magnetic force acting in the same direction along the unchanged x-axis. At an infinitesimal distance along the x-axis from the origin $\mathbf{e}$ and $\mathbf{h}$ will no longer be collinear, but can be made so again by suitable orientation of the axes through infinitesimal angles. Thus a continuous line, characterised at every point by the collinearity along it of the transformed $\mathbf{e}$ and $\mathbf{h}$ may be constructed in the space-time, a procedure precisely analogous to that of constructing a line of force in an electrostatic field. The author then obtains the transformation of the electromagnetic equations into terms of these lines, and shows that out of the lines four mutually perpendicular tubes can be constructed containing each point, and each is characterised by the constancy of the flux of the quantity

$$\mathbf{R} = (\mathbf{E}^2 + \mathbf{H}^2)^{\frac{1}{2}} = \left\{\mathbf{E}^2 - \mathbf{H}^2)^2 + 4\mathbf{E}^2\mathbf{H}^2\right\}^{\frac{1}{4}} = \left\{(\mathbf{e}^2 - \mathbf{h}^2)^2 + (4\mathbf{eh})^2\right\}^{\frac{1}{4}}$$

over its cross-section. A complementary theorem for each tube relating to the twist of its generating lines determines the internal constitution of $\mathbf{R}$ as expressed by the ratio of the magnetic to the electric force present in the compound vector is shown to follow also from the above-mentioned equations. The geometrical construction employed in obtaining the electromagnetic lines leaves their directions in hyperspace subject to some arbitrariness, what is uniquely fixed in hyperspace being, not the direction of the axes, but the orientations at the point of the planes xl and yz, in which the axes are arbitrarily drawn. $\mathbf{R}$ is of the six-vector type, being a function of position associated with two absolutely orthogonal planes uniquely fixed at each point of the four-dimensional field, but degenerates to a five-vector through its real and imaginary parts being equal, consisting of $\mathbf{R} = (\mathbf{E}^2 + \mathbf{H}^2)^{\frac{1}{2}}$ associated with the yz plane (by being perpendicular to it) and iR similarly associated with the xl plane. G. W. DE T.

70. *Faraday Tube Theory of Electromagnetism.* **W. G. Brown.** (Roy. Soc. Edinburgh, Proc. 42. 2. pp. 225–246, 1921–1922. Phil. Mag. 44. pp. 594–609, Sept., 1922.)—An attempt is made to reconstruct the quantitative theory of Faraday tubes on a dynamical basis from a minimum of hypotheses, and a mathematical theory is outlined which leads to the ordinary equations of the electromagnetic field. The theory also gives explicit expression to the ideas of electromagnetic stress, momentum and flux of energy, and gives an electromechanical picture of radiation. A hypothesis is further speculated on, which would satisfy the law of gravitation and would identify gravitational with electromagnetic mass. In a biographical note, the chief events in the life of this brilliant young student and his death at Beaumont Hamel in 1916 are recorded.

G. E. A.

DISCHARGE AND OSCILLATIONS.

71. *Three Magnetically Coupled Circuits.* **E. Takagishi.** (Phil. Mag. 44. pp. 373–376, Aug., 1922.)—The author having found slight errors concerning the damping coefficients in an article by Jackson [Abs. 1932 (1921)] on the same subject corrects them in the present article. E. B.

72. *The Effect of Photoelectric Material on the Thermoelectric Current in High Vacuum Audion Bulbs.* **T. W. Case.** (Optical Soc. America, J.

6. pp. 639–640, Aug., 1922.)—The author has introduced into thermionic valves photoelectric materials, such as barium and strontium, and the photoelectric effect can be caused to control the thermionic current between filament and plate, as this rises greatly with small changes of light intensity, but the change is not directly proportional to the light intensity. The construction of such valves is briefly discussed and the author states that electronegative elements should be tried which would, on illumination, cause a decrease of the thermionic current. **B. J. L.**

73. *Motion and Charge of Electricity Carriers in the Cylinder Condenser.* **W. Deutsch.** (Ann. d. Physik, 68. 4. pp. 335–344, Aug. 17, 1922.)—By means of ionisation by collision (in the cylinder-condenser) suspended bodies were so strongly charged by the free ions that they attained velocities of the order of some cms. per second in a field of 1 c.g.s. unit. **A. B. W.**

74. *A Study of the Luminous Discharge in Hydrogen and in Mercury, and a New Method of Measuring Ionisation Potentials.* **G. E. Gibson** and **W. A. Noyes, Jr.** (Am. Chem. Soc., J. 44. pp. 2091–2106, Oct., 1922.)—In a previous article [see Abs. 123 (1922)] the authors have described some experiments on the obliteration of the characteristic spectra of metals by certain gases. The sparking potentials of these gases relative to air were determined, and it was found that the gases which had a marked obliterating effect also had a high sparking potential. The method used for determining the sparking potential was, however, only roughly quantitative, and the present investigation has been undertaken with the object of obtaining a more precise measure of the voltage required to produce a luminous discharge in a gas. Section II describes experiments on the luminous discharge in hydrogen, dealing with general conditions for stability of the luminous discharge, and the effect of temperature variation of the filament. The experimental results may be explained on the following assumptions: (1) That the luminous glow can be obtained only when conditions in the tube are such that the positive ions produced by the impact of electrons on molecules of the gas are able to reach the kathode before combining to form neutral molecules. When positive ions reach the kathode, they cause an increase in the number of electrons which escape from it, thus producing the increased current to which the glow is due. (2) The potential gradient in the portion of the tube between the kathode and the place where ionisation first occurs, diminishes as the pressure is diminished until at the minimum of E_d (the measured disappearance e.m.f.) the total potential drop in this region has fallen to a very low value, not more than a few tenths of a volt in the shorter tubes nor more than about a volt in the longest tubes measured. (3) At the higher pressures, ionisation occurs at regions intermediate in position between the anode and kathode. As the pressure is diminished these regions recede from the kathode until at the minimum of E_d, the ionisation occurs only in the immediate neighbourhood of the anode. Section III describes the experimental procedure for hydrogen, and Section IV the results obtained, while Section V is devoted to their discussion. The voltage at which the luminous discharge in hydrogen disappears in tubes furnished with heated tungsten kathodes is found to be a function of the pressure for a given tube, passing through a minimum value which is usually a simple multiple of the ionisation potential, 30·9 ± 0·4 volts.

Section VI details the experimental procedure for mercury, and Section VII gives the results for mercury vapour, in which the disappearance voltage of the luminous discharge is found to be a simple integral multiple of the ionisation potential, $10 \cdot 7 \pm 0 \cdot 4$ volts. H. H. Ho.

75. *Low-Voltage Glows in Mercury Vapour.* **G. Stead** and **E. C. Stoner.** (Cambridge Phil. Soc., Proc. 21. pp. 66–74, May, 1922.)

ELECTRICAL PROPERTIES AND INSTRUMENTS.

76. *Determination of the Dielectric Constants in the Electromagnetic Spectrum of Undamped Oscillations.* **K. Theodortschick.** (Phys. Zeits. 23. pp. 344–346, Sept. 1, 1922.)—A reference to the work of Drude and Colley, and the more recent investigations of Möbius and Weichmann, is followed by a mathematical treatment of the problems involved. For measuring the dielectric constants the resonance method was employed, and the conclusions arrived at may be summarised as follows:—

1. The resonance method with a tube generator is very suitable for measuring the dielectric constants in the region of long electromagnetic waves and permits of a qualitative estimate of the absorption.

2. A conductivity of the order $\sigma = 2 \cdot 10^{-5}$ ohm^{-1} cm.$^{-1}$ does not interfere with the measurement.

3. The dielectric constants of amyl- and isobutyl-alcohol are not dependent on the wave-length in the region of wave-lengths from 26 m. to 182 m. E. F.

77. *Effective Capacity of Pancake Coil.* **G. Breit.** (Phil. Mag. 44. pp. 729–740, Oct., 1922.)—In a former paper [Abs. 642 (1922)] the author has defined the "effective capacity" of an inductance coil, and discussed the conditions of its existence and methods of determining it. He here applies his method to the case of a spiral coil, which he terms a pancake coil. The methods used are frankly approximate, but considered sufficiently accurate for the purpose. His method consists in first computing the distribution of charge on the coil which will satisfy the law assumed for the potential distribution. Then he determines M(x), a factor of the integral constituting the effective capacity C_0. This is done for three cases—the coil unearthed and earthed at the centre and at the outer edge. The electrostatic problem is simplified by the use of elliptical coordinates, and the solution obtained in terms of Legendre functions. The remainder is ordinary integration. The results of the calculation are that, expressed in micro-microfarads, the capacity of the coil when earthed at the centre is $0 \cdot 567\ Ka\mu\mu f$; when earthed at the periphery it is $0 \cdot 330\ Ka\mu\mu f$; and when insulated it is $0 \cdot 252\ Ka\mu\mu f$, when a is the radius of the coil and K is the dielectric constant of the medium. The formula for the earthed capacities is verified on a hexagonally wound spiral, where a is taken as the mean of the radii of the inscribed and escribed circles, the dielectric being air. The calculated and measured values were in each case $16\mu\mu f$ and $9\mu\mu f$ respectively. Measurements were not made more accurately than $1\ \mu\mu f$ on account of the difficulties connected with such measurements. G. W. de T.

78. *Resistance and Capacity of Coils at Radio Frequencies.* **J. H. Morecroft.** (Inst. Radio Eng., Proc. 10. pp. 261–286; Disc., 287–289, Aug., 1922.)—Three methods of measuring the radio-frequency resistance of coils are described :—(1) Alternating-current bridge method ; (2) variation of resistance ; (3) variation of reactance. In all cases continuous-wave excitation is used, the power source in all the measurements described being a 10-watt valve oscillator. Measurements were made of the variation of resistance of various coils, both of solid and stranded wire, as the frequency was increased from zero to 500,000 cycles. The results are given in graphical form, and show that the variation does not follow any simple law. The resistance of "tapped" coils was also investigated, as well as the increase of resistance due to the presence of neighbouring coils. The internal capacities of various coils of different shapes were measured, and the effects of the material of the frame or bobbin on which the coils were wound, of moisture, shellac, terminal connections, etc., on the resistance and capacity of coils were investigated. Finally, solid wire and stranded wire are compared at various frequencies, and numerical data are given on the possible resistances obtainable in actual receiving sets. All the results are exhibited graphically. A. W.

79. *New Applications of Expansion Pyrometer to the Thermal Analysis of Alloys.* **P. Chevenard.** (Rev. de Mét. 19. pp. 546–561, Sept., 1922.)—The paper is a descriptive account of apparatus developed at the Société Commentry-Fourchambault et Decazeville. The expansion pyrometer of the Abbé Nollet and Brongniast type has been considerably improved by the use of a nickel chromium alloy as the expanding element. This is contained in a fused silica tube and the relative expansion indicated by suitable mechanism.

A differential pyrometer has also been made working on the same principle. Two specimens of metal identical in form, one of the material under test, the other the standard for comparison, are contained in two tubes. Each is bored along its axis to take the expanding rod of the pyrometer. The differential expansion of the two rods and the actual expansion of the one in the standard sample are recorded optically. Simple apparatus has also been developed to determine the effect of temperature on the resistance, thermoelectric power, and magnetisation of alloys. E. G.

80. *Velocity of Electrons in Gases.* **J. S. Townsend.** (Phil. Mag. 44. pp. 384–386, Aug., 1922.)—Attention is directed to certain misinterpretations by H. F. Mayer (Jahr. der Radioactivität und Elektronik, 18. p. 201, April, 1922) of the author's formula [see Abs. 743 (1912)] for the velocity of ions or electrons in gases due to electric force. Mayer applies a formula specifically stated by the author to refer to *large* ions, to determine the velocity of ions of *small* mass or electrons. The formula given by Lenard is unlikely to be more correct than other proposed formulæ, as the distribution of velocities amongst the electrons is not taken into account. J. S. G. T.

81. *Direct Capacity Measurement.* **G. A. Campbell.** (Optical Soc. America, J. 6. pp. 641–658, Aug., 1922.)—Measurements of "direct capacity" make it possible to control cross-talk in telephone circuits, and to determine more completely how telephone circuits will behave under different conditions. In making measurements for this purpose alternating currents of telephone frequency are used, and Colpitts' bridge method is recommended. Direct capacity, direct admittance, and direct impedance are defined as the branch constants of the particular direct network which is equivalent to any electrical system. For example, if terminals 1, 2, 3, and 4 are joined, 1 and 2 by a capacity C_{12}, 2 and 3 by C_{23}, 3 and 4 by C_{34}, and so on for every pair of terminals, $G_4 = C_{14} + C_{24} + C_{34}$ is the earthed capacity of 4 and the direct capacity between 1 and 2 is $C_{12} + C_{14}C_{24}/G_4$, with similar expressions for 1, 3 and 2, 3. Similar expressions can be obtained with any number of terminals and capacities; and the direct capacities of an electrical system, with u given accessible terminals, are defined as the $u(u - 1)/2$ capacities which, connected between each pair of terminals, will be the exact equivalent of the system in its external reaction upon any other electrical system with which it is associated only by conductive connections through the accessible terminals; thus, in the above example, 4 may be regarded as a concealed branch point, the direct capacities between the pairs of accessible terminals 1, 2, and 3 being as stated. In Colpitts' bridge a double adjustable condenser is employed, arranged so that by rotating a metal half cylinder into different positions with respect to two half cylinders, coaxial with it and connected to two opposite bridge terminals, capacity can be removed from one arm of the bridge and added to the adjacent one as required. The direct capacity to be measured is placed in one of these arms, balanced, and then shifted to the other arm and balanced again. Another method described is that of the null impedance bridge. It is assumed that an electron tube gives an invariable, true, negative resistance. Three of the bridge terminals are joined by a Y network, made up of two resistances R and a negative resistance R/2; the bridge may be given any ratio Z_1/Z_2 by employing a Y made up of resistances Z_1, Z_2 and $-Z_1Z_2/(Z_1+Z_2)$. Maxwell's discharge method accurately compares two direct capacities by means of a single null setting, if all the capacities are free from leakage and absorption, and requires the irreducible minimum amount of apparatus. Several other methods of measurement are described; shielding the bridge, so that any possible movement of the observer or of the apparatus will not affect the result, is recommended; and the measurement of direct admittance and direct impedance is described. H. N. A.

82. *A Form of Iron-Clad Thomson Astatic Galvanometer.* **B. J. Spence.** (Optical Soc. America, J. 6, pp. 696–700, Sept., 1922.)—The instrument described is a semi-portable astatic galvanometer of high sensibility, has a removable core, containing coils and suspended magnet system, is light, and is easily adjusted to a high sensibility. The four coils were wound on a mandrel, whose surface was shaped approximately according to Maxwell's expression, with enamelled wire, boiled in 50 % resin and 50 % beeswax; they were cemented into circular holes, two of which were cut in each of the two halves of a split, hollow, brass cylinder, with a removable head, containing a screw which carries the fine quartz fibre, to which the suspended magnet system is attached. This core can be slipped into an axial hole bored in a cylinder of Swedish iron, a conical hole through the side of which allows the mirror to be observed. A weak magnet of watch or clock spring, covered with paper, shellacked and clipped on to the cylinder, enables the zero to be controlled, and the instrument adjusted for high sensitivity. A sensitivity of 8×10^{-12} amperes, with a period of 3 sec., was obtained by increasing the shielding and operating the system *in vacuo*. H. N. A.

83. *A Low-Voltage Kathode Ray Oscillograph.* **J. B. Johnson.** (Optical Soc. America, J. 6. pp. 701–712, Sept., 1922.)—In the ordinary Braun oscillograph the electron stream is produced by a high-voltage discharge, 10,000 to 50,000 volts are required, and it is expensive, non-portable, and dangerous. The author has introduced a Wehnelt kathode as a source of electrons, and the oscillograph can now be used at 300 to 400 volts, the lower limit only being determined by the effect of the electrons on the fluorescent screen. This tube is illustrated, and differs somewhat from the usual Braun tube, details, with diagrams, being given of the focusing arrangements, the electrode unit, the thermionic filament, the deflecting elements, and the fluorescent screen, which is spread on the inner surface of the tube, a correction being given for the distortion caused by the curvature of the tube.

The function of the gas in the tube with reference to the focusing arrangements is dealt with at length; the focus is more readily obtained with heavy gases, as nitrogen, argon, and mercury vapour, than with light gases as hydrogen and helium. In practice argon is used, since this does not attack the electrodes. Examples of the use of the tube is illustrated for the determination of the hysteresis curve of iron, the characteristic curve of a vacuum valve, and the modulation of high-frequency currents. B. J. L.

84. *An Improved Form of Nichols Radiometer.* **B. J. Spence.** (Optical Soc. America, J. 6. pp. 625–628, Aug., 1922.)—The Nichols radiometer, as usually constructed, consists of a pair of mica vanes fastened by fine glass rods to a glass staff with a mirror attached for purposes of observation. The system is suspended by a fine quartz fibre in a container pumped out to a pressure of 0·02 mm. Hg. The author has constructed an instrument in which the period of vibration has been reduced from 60 to about 8 seconds by reducing the moment of inertia of the suspended system. Two strips of phosphor bronze ribbon 0·13 mm. wide, 0·018 mm. thick, and 15 mm. long, are used for vanes, being about 4 mm. apart, held by finely drawn glass cross-pieces. The system is suspended by a fine quartz fibre in a thick-walled cylindrical iron chamber. The sensitivity obtained is equal to that of a Bi-Sb, Bi-Sn thermopile of 20 junctions and 6 mm.^{2} receiving surface in series with a low resistance astatic galvanometer of sensitivity 3×10^{-10} amps., and is superior to this instrument in being free from zero drift and fluctuations. The instrument has been employed by the author in the study of some infra-red absorption spectra. T. B.

ALTERNATING CURRENTS AND MAGNETISM.

85. *The Relation between Magnetic Hysteresis Loss and Coercivity.* **N. L. Anderson** and **T. M. C. Lance.** (Engineering, 114. pp. 351–352, Sept. 22, 1922.)—If H_c is the coercivity and B_m the maximum induction the ratio $(\int H dB)/(2H_c \times 2B_m) = K$ has been found, for any one material, to increase slightly with increase of B_m [Abs. 1291B (1906)]. The present paper deals with the dependence of K on B_m. A ring made of stampings of high-grade transformer iron was investigated. Hysteresis loops were obtained by (1) method of reversals, (2) step by step, (3) slow cycle method, and the values of K plotted against B_m. The relation obtained is $K = 0{\cdot}66 + 0{\cdot}000032\ B_m$ ($K = 1$ for $B_m = 10{,}000$ approx.). The hysteresis loss is influenced by the method employed. The authors then collate data for stalloy and cast iron obtained by F. Stroude by the slow cycle method and their own observations on transformer iron by the same method. The relation obtained is $K = 0{\cdot}67 + 0{\cdot}000032\,B_m$. Finally data obtained by ballistic methods by various observers on different magnetic materials (cast iron, cobalt, silicon-iron, etc.) are treated similarly, the relation being $K = 0{\cdot}67 + 0{\cdot}000034\,B_m$. The authors are of opinion that if magnetic materials of widely differing properties are dealt with in the same form and subjected to the slow cycle method of magnetisation, then a general relation between K and B_m is possible. The practical application of such a general equation to the calculation of hysteresis losses and demagnetising force under specified conditions is then pointed out. L. L.

86. *Magnetic Permeability of an Artificial Magnetic Medium.* **H. Maurer.** (Phys. Zeits. 23. pp. 346–347, Sept. 1, 1922.)—A criticism of Goldhammer's results [see Abs. 2326 (1922)] for the permeability of a space partially occupied by steel balls. The observed increase of permeability with increase of field from 100 to 341 gauss is in contradiction to the calculated decrease, and it is doubtful whether a value calculated from Landolt's tables is satisfactory. An experimental determination of μ for the steel used is considered necessary. G. E. A.

87. *Influence of Small Quantities of Iron on the Susceptibility of Diamagnetic Elements.* **O. E. Frivold.** (Ann. d. Physik, 68. 4. pp. 356–368, Aug. 17, 1922.)—In a previous paper [Abs. 340 (1919)] the author has described measurements of the susceptibility of a number of elements with a view to testing the theory of Gans according to which the principal moments of inertia of the magneton can be calculated from a knowledge of the dependence of the susceptibility on field strength. The experimental data for Au were used to evaluate these constants, but the values deduced are greater than those obtained by methods based on different principles. In addition, the data lead to the unsatisfactory result that the number of magnetons is smaller than the number of atoms per gram atom. The measurements of the susceptibility of Au have been repeated, but substantially the same results obtained. The presence of small quantities of iron in other elements investigated will have a decided effect on the results, and this will depend whether the iron is held in combination or is present as a mixture. To elucidate this effect the author describes measurements of the susceptibility of alloys of Ag and Zn with Fe. Using the finest jeweller's silver (0·12 parts of Fe per 1000) this is found to be paramagnetic in weak fields. Pure silver, prepared electrolytically from this, had a constant susceptibility up to the maximum field used (4000 c.g.s.). Casting this silver either in the air or in an atmosphere of N has no sensible influence on the magnitude of the susceptibility. Confirmatory control experiments were performed starting with pure electrolytic silver and adding iron. In the case of Zn-Fe alloys, where mixed crystals are formed, the presence of iron has a smaller effect on the susceptibility. The results for small additions agree with those obtained by Lehmann (up to 1·23 parts per 1000) [Abs. 652 (1922)]. For greater iron content (3·59 and 10·07 per 1000) the author obtained a positive susceptibility. This is contrary to Lehmann's investigations, but is possibly due to the different mode of preparation. L. L.

88. *Applications of the Heterodyne Beat Method to Physical Measurements.* **M. H. Belz.** (Phil. Mag. 44. pp. 479–501, Sept., 1922.)—A more complete account is given of the method and results published in a previous paper [see Abs. 2330 (1922)]. The precautions for attaining steadiness of the beat note are detailed, and it was found that the "B" valve of the General Electric Co. was best suited for this object. The eddy-current effect in the substance under test was examined, and the change in the beat note was noted when wires of different conductivity were placed within the coil whose inductance is one of the determining factors in the frequency of the oscillations in the circuit. The effect of the eddy currents in the test material was found to be negligible. The theory and results of the method as applied to the determination of the magnetic susceptibility of salts are then set forth. G. E. A.

89. *27-Day Period (Interval) in Terrestrial Magnetism.* **C. Chree.** (Roy. Soc., Proc. 101. pp. 368–391, Aug. 1, 1922.)—The 27-day interval has been considered by the author in several previous papers, but the present is based on two series of data, extending over a much longer time, and consisting of (*a*) international "character" figures for 15 years (1906 to 1920) and (*b*) daily ranges in the Kew declination curves for 42 years (1858 to 1900, omitting 1874). In both cases the criterion of disturbance adopted is the difference of the individual from the corresponding mean monthly values. The period is found not only in disturbed days (or, in the Kew data, days of largest range) but also in quiet days (or days of least range). Its length appears to be slightly over 27 days. Considering mean annual values, low sun-spot frequency and low sun-spot latitude are both conducive to its development, but there is no indication of any variation in its *length* associated with variations in these quantities. The 27-day interval is found throughout the year and there is no evidence of any seasonal variation in its length or in the degree to which it is developed.

The 27-day interval is held, as a result of this investigation, to be just as real a characteristic of the quiet as of the disturbed days, and the view is taken that the difference between magnetic disturbance and magnetic calm only amounts to irregularity in a constantly operating solar discharge, whose source is not confined to sun-spots. The latter may be either specially vigorous sources or merely visible evidence of special activity. M. A. G.

90. *Periodicity of Activity in Terrestrial Magnetism and the Rotation of the Sun.* **G. Angenheister.** (Terrest. Magn. 27. pp. 57–79, March–June, 1922.)—A more detailed paper in support of the hypothesis previously advanced [see Abs. 1725 (1922)] that the greater magnetic storms, which exhibit a periodicity of approximately 30 days, arise from deep-seated disturbances in the sun which may persist for a period of years, whereas the 27-day periodicity in smaller disturbances and quiet times, investigated by Chree [see preceding Abs.] is associated with more transitory disturbances in the higher solar strata. M. A. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY

91. *The Adsorption of Ions.* **J. N. Mukherjee.** (Phil. Mag. 44. pp. 321–346, Aug., 1922.)—It is recalled that the main so-called physical theories to account for adsorption have been developed by Gibbs, from the standpoint of thermodynamics, J. J. Thomson, Milner, Lewis, and Donnan and Barker, and on the experimental side by Freundlich, who adopts the standpoint of Gibbs that adsorption is due to a decrease in surface tension. Arrhenius adduces evidence of the compressed state of the surface layer in the adsorption of gases by charcoal, and at the same time lays stress on the factor of chemical attraction. The chemical theory has been developed by Langmuir, who attributes adsorption to the chemical affinities of the surface atoms.

Adsorption of ions leads to an electrically charged surface, the amount of charge depending only on the total number of ions (of both signs) fixed per unit area of surface. Kataphoretic and electro-endosmotic experiments give a quantitative idea of the relative adsorption of both ions. The electrical charge helps to peptise the adsorbent, and a quantitative idea of the adsorption of ions can be formed from peptisation by electrolytes. A criticism is given of the different theories which have been put forward to account for the following outstanding phenomena in ionic adsorption :—(*a*) The equation of the adsorption-isotherms in accordance with which, with monovalent ions, the density of charge on an adsorbing surface increases with the concentration to a maximum ; and, at higher concentrations, falls gradually to a small value ; while with multivalent or complex organic ions, the charge passes through a null value, becomes reversed in sign, and again reaches a second maximum, after which it falls slowly. (*b*) $H^{\cdot}$ and OH' ions behave exceptionally in that they impart to the surface a charge of the same sign as they carry. (*c*) Adsorption of solvent. (*d*) Theories regarding the exchange of ions. (*e*) Rôle of electrostatic forces in the adsorption of ions. (*f*) Exchange of bases in soil and soil-activity. (*g*) Adsorption of ions in its relation to permeability of membranes and to negative osmosis. J. N. P.

92. *The Adsorption and Orientation of the Molecules of Dibasic Organic Acids and their Ethereal Salts in Liquid-Vapour Interfaces.* **H. H. King** and **R. W. Wampler.** (Am. Chem. Soc., J. 44. pp. 1894–1902, Sept., 1922.)—In the case of solutions of different concentrations of organic acids and esters, measurements were made of adsorption by means of the Gibbs equation and of surface tension by a drop-weight apparatus. The surface adsorption of the dibasic acids is found to be less than that of the monobasic acids and to increase with the carbon content, though the increase is not regular for each carbon atom added to the chain. The presence of an hydroxyl group raises the surface tension as shown by malic and *d*-tartaric acids, the latter of which gives negative adsorption. Esters are adsorbed more than acids, due to the replacement of the polar carboxyl group by the group $- C(= O) - O - Et$. The results are in accordance with the theory that the polar group or active end of the molecule is turned towards the interior of the liquid, the slightly polar group projecting up to form the surface layer, and the potential energy of these groups determining the surface tension. Catalysis, in accordance with this theory, is also to be attributed to capillarity, whereby, through adsorption, increased concentration of the reactants occurs at the surface. J. N. P.

93. *The Adsorption of Uranium-X and its Isotype Thorium by Basic Ferric Acetate.* **A. C. Brown.** (Chem. Soc., J. 121. pp. 1736–1743, Sept., 1922.)—Freundlich's empirical formula for adsorption is $x/m = ac^{1/n}$, where x is the amount adsorbed, m the amount of adsorbing substance, c the end concentration of the solution, a a constant depending on the substances and units used. According to Freundlich $1/n$ is always less than 1, generally between 0·1 and 0·5. Biltz and Boswell and Dickson have shown that when arsenious acid is adsorbed by ferric hydroxide $1/n$ increases with decreasing concentration, its average value being about $1/5$. Georgievics found $1/n = 1$ for dyes in very dilute solutions, adsorbed by cotton fibres. Ritzel found $1/n = 1$ for the adsorption of uranium-X by charcoal, the addition of a trace of thorium prevented the adsorption of UX. A. C. Brown deduces that, if it is accepted that UX and Th are not separable by adsorption, the value of $1/n$ must decrease with increasing concentration of the element "atomic number 90," because, if it remained equal to 1, increasing concentration would not alter the ratio of the amount of element adsorbed to that in solution. The adsorption of uranium-X from a solution of uranium acetate, containing no thorium, by basic ferric acetate was measured by means of its β activity. The measurements were repeated with solutions of the same concentration, to which small amounts of thorium had been added. A graph was prepared, with log x/m as ordinates and log c as abcissæ, where c is the concentration of element "atomic number 90." This shows that in the absence of thorium, and with small quantities of the same, $1/n = 1$; but with increasing concentration $1/n$ diminishes. Thus Freundlich's law is strictly true over the region where $1/n = 1$. The fall in the value of the exponent with increasing concentration is in general agreement with Langmuir's theoretical deductions on the adsorption of gases at solid surfaces. It is intended to carry out similar experiments with surfaces of known area, and to investigate the part of the curve at the solubility limit. Such minute quantities of radioactive substances can be measured that it has become possible to study adsorption at the most interesting stage, when the first layer of atoms or molecules is being deposited. H. N. A.

94. *Experimental Attempts to Decompose Tungsten at High Temperatures.* **G. L. Wendt and C. E. Irion.** (Am. Chem. Soc., J. 44. pp. 1887–1894, Sept., 1922.)—The secondary circuit of a transformer was connected to the two sides of a large condenser, one side leading through a heated kathode rectifier. The discharge circuit led from the two sides of the condenser across a spark gap formed by two 2-cm. brass spheres and through a tungsten wire of 0·035 mm. diam. and 4 cm. long which was supported between electrodes of thicker tungsten wire mounted, by direct sealing, in a surrounding spherical vessel of strong Pyrex glass. The vessel also contained a smaller side tube with a sealed-in electrode. This, together with one of the other electrodes which was used as the second terminal, served for the spectroscopic examination of the gas within. In the first series of experiments the bulb was evacuated to a very high degree, and by the passage of a non-oscillatory discharge the tungsten wire was caused to explode. After a complete explosion the formation of dust, smoke, or solid residue was not in any instance observed, but a quantity of gas was obtained. Spectroscopic measurement disclosed the presence of traces of mercury (attributable to back diffusion from the pump) and a marked yellow line of helium, together with other fainter lines which have not yet been identified. Both hydrogen and neon were absent, which is in accordance with the observation of Rutherford that, by the bombardment of α-rays, the production of hydrogen only occurs in the case of elements whose atomic weights are not multiples of 4.

In a second series of experiments, the vessel was filled with highly purified carbon dioxide, and the gas produced by the explosion was measured by absorbing the contents of the vessel by a solution of potash. The residual gas thus obtained amounted to 1·01 c.c. for a wire of 0·713 mgr. weight, the theoretical amount of helium corresponding to the decomposition of this weight of tungsten being estimated to amount to 4 c.c. The gas has not yet been completely analysed. The absence of any appreciable amount of carbon monoxide was demonstrated, and blank tests have shown that the gas produced could not be attributed to any form of contamination. The temperature attained by the explosion is estimated at 20,000° C. J. N. P.

95. *Action of Light on Suspensions.* **R. Audubert.** (Ann. de Physique, 18. pp. 5–83, July–Aug., 1922.)—The growth of grains of colloidal sulphur is more rapid in violet light than in the dark. In addition, radiations of short wave-length increase the intensity of adsorption of ions by grains of gum mastic, whilst radiations of long wave-length diminish the adsorption. Radiations of intermediate wave-length are inactive, and these exhibit a minimum of absorption by the colloidal suspensions. T. M. L.

96. *New Physico-Chemical Law.* **H. Collins.** (Chem. News, 125. pp. 81–83, Aug. 18, and pp. 97–98, Aug. 25, 1922.)—From the atomic weights and specific gravities of various elements, and the specific gravities and heats of formation of several common molecules, are deduced the relative volumes of the elements when in combination and the heat of formation of each element when combining to form molecules. The results thus obtained show that the heat of formation of an element is proportional to the product of the atomic weight and the change of volume; the calculated results do not differ from the observed values by more than 1 per cent. except in a few cases which are probably explainable by inaccuracy in the observed heats of formation. T. H. P.

97. *Thermodynamic Treatment of the Possible Formation of Helium from Hydrogen.* **R. C. Tolman.** (Am. Chem. Soc., J. 44. pp. 1902–1908, Sept., 1922.)—The equation 4H = He is treated thermodynamically as representing a chemical reaction, but as being accompanied by a decrease of mass. By a combination of the older treatment with the relationships developed in the theory of relativity, expressions are successively developed for the heat, entropy change, free energy change, and equilibrium of the reaction, and the conclusion is arrived at that no appreciable amount of monatomic hydrogen can exist in equilibrium with helium at temperatures below a million degrees and pressures above 10^{-100} atmospheres. The conflict between this conclusion and the mutual presence of hydrogen and helium under terrestrial, solar, and stellar conditions is discussed.

A. B. C. L.

98. *Determination of the Space Group of a Cubic Crystal.* **R. W. G. Wyckoff.** (Am. J. Sci. 4. pp. 175–187, Sept., 1922.)—Only in few cases has it yet been found possible to determine the space group to which a particular crystal should be assigned on the basis of direct experimental evidence. For crystals having any atoms of appreciable scattering power in general positions, criteria are now established for ascertaining from studies of Laue photographs the space group to which a crystal of the cubic system belongs. Many of the space groups give diffraction effects different from those given by any other groups and hence in the cases of crystals assignable to any of these unique space groups, a method is provided of defining completely crystal symmetry without utilising the older methods such as face development, etc.

T. H. P.

99. *An Inhibition Period in the Separation of an Emulsion.* **T. C. Nugent.** (Faraday Soc., Trans. 17. pp. 703–707; Disc., 708, May, 1922.)—Concentrated emulsions of 50 % (by volume) of benzene in water were made using 0·1 % or more of gelatine as a stabiliser. The addition of sodium hydrate solution brings about de-emulsification, which is attributed to the destruction or breaking down of the protecting layers, the gelatin being transformed into some less colloidal condition. The rate at which benzene separates from such an emulsion on the addition of sodium hydrate increases with time, which is probably due to the continuous decrease in the viscosity of the system. For any given concentration of gelatin, there is found to be an inhibition period, or time lag, in the separation which is proportional to the time elapsing between the actual preparation of the emulsion and the addition of the alkali. With 0·4 % gelatin solution, the equation to the curve showing the relation between the age of an emulsion and the inhibition period is $X = 30{\cdot}11\,y^{0{\cdot}2135}$ where X is the inhibition period and y the age of the emulsion. With increasing values of y, X converges towards a limiting value known as the "limiting inhibition period" which increases in a linear manner with increasing content of gelatin. The inhibition period is considered to be a measure of the amount or thickness of the gelatin adsorbed, and the age of the emulsion as the time required to produce a given amount of adsorption, while the limiting inhibition period represents the final equilibrium quantity adsorbed from the corresponding concentrations of gelatin in the bulk of the continuous phase.

J. N. P.

100. *The Influence of the Size of Colloid Particles upon the Adsorption of Electrolytes.* **H. D. Murray.** (Phil. Mag. 44. pp. 401–414, Aug., 1922.)—The influence of the size and uniformity of colloid particles upon the adsorption of electrolytes is measured by the minimal concentration of the latter for coagulation. Particles of gum mastic were prepared of different mean sizes by fractional coagulation with varying concentrations of hydrochloric acid followed by centrifuging, redispersing the precipitate in water and dialysing to remove the last traces of acid. The density of the particles in the solution was determined with a pyknometer, the residue after evaporating a known volume being also weighed. The number of particles was counted by means of an ultra-microscope with a cardioid condenser. A known small volume of the solution was diluted to a definite degree so that about 4 particles appeared in the field of view. The interfacial surface is represented by $r^2 \times n$, where r is the mean radius of the particles calculated from the above data and n the number of particles in unit volume. Electrolytes of different concentrations were added to the mastic solutions, and the time recorded for the formation of large flocks leaving the medium clear. With more dilute solutions the point of complete coagulation was found to be determined best by centrifuging the solution at a constant speed after standing 48 hours. If not coagulated within this time no further change occurred on standing. Values are obtained of the limital concentration of electrolyte to coagulate different concentrations of mastic, and the relation between the concentrations and the interfacial surface of the colloid is found to be represented by uniform curves. Though adsorption appears to be largely conditioned by the amount of interfacial surface exposed, it is found that the minimal concentration of electrolyte is higher throughout for small particles than for large. This is explained by the view that the critical value to which the surface charge must be reduced before coagulation begins is lower with smaller than with larger particles. This theory is in accordance with the known fact that the surface tension of large particles is greater than that of small ones. J. N. P.

101. *The Effect of Cold Work on Commercial Cadmium.* **J. N. Greenwood.** (Faraday Soc., Trans. 17. pp. 681–687; Disc., 687, May, 1922.)—This is an account of investigations made on cast and hammered cadmium, to determine the relations between hardness, ageing, and annealing. Tests made on ingots (99·75 Cd and 0·25 Pb) cast, and the cast and hammered metal indicated a fairly constant Brinell hardness for the cast metal, but the hammered metal was softer and the hardness progressively decreased with age. Most soft metals such as aluminium, magnesium, and tin show increased hardness, followed after 5 to 15 days by a progressive decrease. Microscopic investigation of the structure showed a progressive refinement of the grain, i.e. at ordinary temperatures cadmium is capable of spontaneous annealing. On the other hand chill-cast cadmium undergoes spontaneous recrystallisation at ordinary temperatures without cold working. The author concludes that two different forms of cadmium were dealt with, and that quick cooling by chill casting suppresses the transformation point. Recrystallisation and hardness tests indicate the allotropic change-point at about 60° C. Cast cadmium exhibits spontaneous recrystallisation after about 12 days, indicating in the light of Smits' theory of allotropy a gradual change from Cd_β to Cd_α, the two modifications being mutually soluble until at a certain critical state recrystallisation takes place in the stable form. From hardness determinations Cd_α appears to be stable between 20° C. and 60° to 65° C., whilst Cd_β is stable between 65° C. and 140° C.—the highest temperature observed. The paper is well illustrated with curves of hardness, temperature, and time, and microphotographs are given. A. W. J.

102. *Thermal Acid Test of Aluminium.* **F. Mylius.** (Zeits. f. Metallkunde, 14. pp. 238–244, June, 1922. From the Reichsanstalt.)—When aluminium is placed in hydrochloric acid, hydrogen is liberated, and the temperature of the acid rises to 50° and more within a period which depends upon the purity, size, and surface condition of the specimen. In making the test in 10 % HCl with 0·5 g. of metal, the author cleans the metal first in 1 % caustic soda, which removes the surface film of oxide and rolled-in impurities (iron, oil). A temperature maximum is reached within a few minutes when the metal is impure, or within 30 minutes and more when pure. The experiments are made at 20°, and the rate of temperature rise $(t - 20)$ in deg. C. per minute ranges from a little above 0 up to 20° and more. A classification of technical aluminium and its alloys based upon this rate is proposed. The alloys may belong to various classes. H. B.

103. *Dilatometer Tests of Alloys of Low Melting-Points; Dental Alloys.* **K. Gilbert.** (Zeits. f. Metallkunde, 14. pp. 245–253, June, 1922.)—The tests are made with 40 gr. of material in a dilatometer after Würschmidt and Köller, which is not described in detail. The alloy Sn_9Pb gave a sharp maximum expansion at 183·8° and again at 220° (smaller maximum); the alloy SnSb behaved similarly, but the curve descended before the first maximum; Sn_7Pb_3 only showed the first maximum. In the alloys of bismuth and tin the influence of bismuth was very strong even with high percentages of tin, and these alloys further contracted slowly, but almost regularly, when kept for hours or days at the same temperature, especially at relatively high temperatures (180° in the case of Sn_3Bi_2). The ternary alloy Sn-Pb-Bi gave a curve with a pronounced minimum at 94·9°, followed by a sharp maximum at 112·8°, and continued to contract uniformly when kept at 18·5° for 12 days. H. B.

104. *Density Determinations of Metals and Alloys, Solid and Liquid; Cu-Sb, Cu-Zn, Al-Zn.* **K. Bornemann** and **F. Sauerwald.** (Zeits. f. Metallkunde, 14. pp. 254–258, June, 1922.)—The further experiments [Abs. 2021 (1922)] show that the specific volume v of antimony increases from 0·1555 to 0·1607 as the temperature rises from 708° to 1041°. Zinc, and also its alloys, caused difficulty owing to the high vapour pressure and the adhesion of air bubbles; the v rose from 0·1585 at 690° to 0·1607 at 805°. In the alloys of Cu-Sb the v is smaller than it would be in simple mixtures; compounds, possibly Cu_5Sb_2 or Cu_3Sb, seem to persist in the liquid state. In the case of Cu-Zn the compound Cu_2Zn_3 seems similarly to exist in the liquid; the conclusion is supported by the chemical and electrochemical properties. The v of Al-Zn alloys is, however, proportional to the concentration, and the solid compound Al_2Zn_3 would therefore not persist in the liquid state. H. B.

105. *Rapid Calculation of Theoretical Maximum Temperatures.* **G. G. Brown.** (Chem. and Met. Eng. 27. pp. 497–500, Sept. 6, 1922. Revised paper read before Am. Chem. Soc., Sept., 1921.)—A method is described for the determination of the temperatures developed by chemical reactions (such as those during the combustion of fuel or the detonation of an explosive) by using an equation of the form $Q = at + bt^2$ in which Q is the heat of reaction, $a + bt$ the specific heat of the products, and t the temperature attained. Systems are devised for the convenient evaluation of t from the quadratic equation by means of algebraic methods, slide-rule readings, and by a graphical chart. No allowance is made for the changing heat of reaction or the displacement of equilibrium with changing temperature. J. N. P.

106. *Radiation and Chemistry.* **J. Perrin.** (Faraday Soc., Trans. 17. pp. 546–572, May, 1922.)—The theory advanced by the author [Abs. 1104 (1919)], some of whose conclusions were arrived at by Lewis [Abs. 814 (1919)], is developed further, and is extended so as to embrace the theory of atoms and the phenomena of radio-activity. The other subjects especially dealt with in their relation to the theory, include: velocity of reaction; independence of the life of a dissociable molecule on the frequency of the collisions; probable action of the radiation; tautomerism; critical molecules, spontaneously transformable; multiple tautomerism; dissociation; law of mass action; formula of Arrhenius; Planck's law; quanta and Bohr's law; photochemical sensitiveness; continuity of the absorption and emission of radiation; transformation of the energy of radiation into energy of agitation and vice versa; intervention of collisions in reactions; action of the corpuscular radiations. The phenomena of photochemistry, luminescence, and organic fluorescence are referred to in experimental verification of the theory, and a number of objections to the theory are critically examined. T. H. P.

107. *Radiation Hypothesis of Chemical Reactivity and some of its Applications.* **W. C. M. Lewis.** (Faraday Soc., Trans. 17. pp. 573–587, May, 1922.)—The author's radiation hypothesis of chemical change, based on Planck's quantum theory, is applied to the explanation of the mode in which the energy necessary for chemical change, in catalytic and in non-catalytic processes, is communicated to the reactant unit [Abs. 814 (1919), 456 (1920), 1206 (1922)]. Criticisms which have been advanced against the hypothesis are discussed. T. H. P.

108. (1) *Chemical Reactions on Surfaces.* (2) *Mechanism of the Catalytic Action of Platinum in the Reactions* $2CO + O_2 = 2CO_2$ *and* $2H_2 + O_2 = 2H_2O$. **I. Langmuir.** (Faraday Soc., Trans. 17. pp. 607–654; Disc., 655–675, May, 1922.)—A summary is given of the evidence for the existence of very stable adsorbed films on solid surfaces, for the monomolecular nature of these films and for the tendency of the molecules to be oriented on the surfaces. The mechanism of adsorption and of chemical reactions on surfaces, and reactions occurring at boundaries of phases are discussed.

When mixtures of carbon monoxide and oxygen at pressures up to a few hundred bars (0·1 mm.) are brought into contact with a smooth platinum surface at 500°–700° K., they react at a rate proportional to the partial pressure of the oxygen and inversely proportional to that of the monoxide. The velocity of reaction increases rapidly with the temperature—about 1·6-fold for 10° at 600°. With platinum at 750°–1050° K. the velocity is practically independent of the temperature, being limited largely by the rate at which the gases can come into contact with the surface. With excess of oxygen, the velocity is proportional to the pressure of monoxide, whilst with excess of monoxide the rate is proportional to the pressure of the oxygen.

A theoretical quantitative analysis of the results indicates that every oxygen molecule which strikes a clean platinum surface condenses as single atoms combined with separate platinum atoms so firmly that even at 1500° K. evaporation of the oxygen atoms is inappreciable. Such adsorbed oxygen atoms are so active that every carbon monoxide molecule striking them reacts to form dioxide. All monoxide molecules striking a clean platinum surface condense, being held by chemical union between the carbon atom and two platinum atoms. Thus, an adsorbed film of monoxide consists of a monomolecular layer of oriented molecules, which, however, evaporate appreciably at 500° K. Owing to their orientation these molecules are chemically very inert towards oxygen, and at 500° K. only about one oxygen molecule out of 10^{12} which strike the surface, reacts with the monoxide. The heat of evaporation of adsorbed monoxide is 31,800 cals. per gram-mol., and at 700° K. with a pressure of 1 bar of monoxide, at least one-half of the platinum surface is covered with adsorbed monoxide. In the low-temperature range the surface is almost completely covered by a monoxide film, and the reaction occurs only when monoxide molecules strike oxygen atoms which have become adsorbed in the spaces left vacant by the evaporation of monoxide molecules. In the high-temperature range the surface is nearly covered with oxygen when this is in excess, and the reaction velocity is then limited by the rate at which the monoxide strikes the surface. With excess of monoxide the surface is largely bare and the reaction velocity is limited by the rate at which the oxygen strikes the surface, as every oxygen molecule remains on the surface in atomic condition until struck by a monoxide molecule.

At low temperatures (300°–600° K.) somewhat erratic results are obtained for the reaction velocity with mixtures of hydrogen and oxygen, as the velocity depends on the previous treatment of the platinum. When the latter is relatively inactive, the results are similar to those obtained with carbon monoxide and oxygen, the velocity being approximately proportional directly to the pressure of the oxygen and inversely to that of the hydrogen. At high temperatures (700°–1900° K.) the results correspond closely with those given by monoxide, the hydrogen having the same function as the latter; at these temperatures the reaction is not sensitive to the previous treatment of the platinum. These results indicate that the adsorbed oxygen atoms are highly reactive towards hydrogen, every collision between a hydrogen molecule and an adsorbed oxygen atom resulting in combination. Under certain conditions adsorbed hydrogen atoms are relatively inactive towards oxygen molecules, but the platinum can be brought into a condition which enables the adsorbed hydrogen to react with oxygen molecules or with the oxygen adsorbed in adjacent spaces on the surface. T. H. P.

109. *Induced Reactions and Negative Catalysis.* **N. R. Dhar** and **N. N. Mittra.** (Faraday Soc., Trans. 17. pp. 676–680, May, 1922.)—The phenomenon of the induction of a reaction by a second reaction is shown experimentally to be of general occurrence. Oxidation reactions exhibit negative catalysis when the catalyst tends readily to undergo oxidation, and the negative catalysis appears to depend on the formation of intermediate compounds. Investigation of the various cases of induced reactions appears to indicate that one chemical change should induce another chemical change of the same type, but further experimental evidence is required to prove this definitely. T. H. P.

110. *Radiation Theory of Chemical Action.* **F. A. Lindemann, S. Arrhenius, I. Langmuir, N. R. Dhar, J. Perrin, W. C. M. Lewis.** (Faraday Soc., Trans. 17. pp. 598–606, May, 1922.)—Discussion on papers contributed by Perrin, Lewis, Baly, and Lowry [Abs. 106, 107, 111, 112 (1923)]. T. H. P.

111. *Theory of Chemical Action and Reactivity.* **E. C. C. Baly.** (Faraday Soc., Trans. 17. pp. 588–595, May, 1922.)—On the basis of the following three assumptions, which differ from those usually made, it is possible to formulate a theory of absorption of energy: (1) It is assumed first that an elementary atom is characterised not by a free period of vibration, but by a definite amount of energy associated with a specific physical change in the atom, such as the shift of an electron from one orbit to another; on this assumption an atom can gain or lose energy only in terms of this unit or elementary atomic quantum of energy. (2) That the physical change in the atom occupies a definite period of time which is the same for all atoms, the atom then becoming capable of absorbing or radiating energy of a definite frequency. (3) That the elementary quanta of all the known atoms are integral multiples of a fundamental unit, which is possibly the elementary quantum of the hydrogen atom.

The deductions made from these three assumptions lead to a radiation theory of chemical reaction differing from the better-known theories in the essential fact that it does not rest on a basis of monochromatic radiation. The existence is established of simple integral relationships between the various frequencies exhibited by a molecule and of the combination of these frequencies to form subsidiary frequencies within the absorption bands; these relationships have all been observed.

A molecule must exist in one of a number of possible phases, any two consecutive phases differing in energy content by one molecular quantum of energy. Each phase is characterised by its own phase quantum and phase frequency, and is endowed with its own specific reactivity, and a molecule must be brought into the appropriate phase before it can take part in a reaction. Since a molecule in the free state exists in a more condensed phase than the one desired, it is necessary to supply energy to produce the change of phase; such increment of energy is exactly equal to one or more molecular quanta, the number depending on the difference between the initial and reactive phases. The energy may be gained by the molecule on exposure to radiation of frequency equal to its atomic, intra-molecular, or phase frequency. Changes of phase produced by heat and by light have frequently been observed. The effect of temperature is due to the summation within the molecule of an integral number of atomic or intra-molecular quanta to give the one or more molecular quanta required. When the phase change is produced by the absorption of a phase quantum, the balance of energy over that required is radiated as fluorescence or phosphorescence. The increment of energy may be supplied by a material catalyst which forms an addition complex with the molecule. Within this complex one or more molecular quanta are given to the reactant molecule by the catalyst molecule, the former passing into a less condensed, the latter into a more condensed phase. Experimental evidence in support of this theory is mentioned.

T. H. P.

112. *Is a True Monomolecular Action Possible?* **T. M. Lowry.** (Faraday Soc., Trans. 17. pp. 596–597, May, 1922.)—The author criticises the foundation on which Perrin's radiation hypothesis of chemical reaction is based, and challenges the validity of the assumption that a monomolecular action may actually be formulated as one in which single molecules are involved. The only cases of monomolecular actions quoted by Perrin as illustrations do not fulfil this assumption, and the only likely actions of this type are those in which the aid of the radiation hypothesis is unnecessary. **T. H. P.**

113. *Spectroscopic Measurements of the Hydrogen Ion Concentration Colour Changes in Recent Indicators.* **T. T. Baker** and **L. F. Davidson.** (Phot. J. 62. pp. 375–379, Aug., 1922.)—The absorption curves are given of a number of the newer indicators at their extreme ranges and in some cases in an intermediate colour. Very slight changes in hydrogen ion concentration often produce an extraordinary effect on the absorption. Thus, with bromocresol purple a minute trace of alkali completely changes the character of the ultra-violet absorption. The same is the case with bromothymol blue, with which an alkali in presence of a buffer salt produces only very slight intermediate changes. **T. H. P.**

114. *Electrification at the Boundary between a Liquid and a Gas.* **H. A. McTaggart.** (Phil. Mag. 44. pp. 386–395, Aug., 1922.)—In continuation of previous work [see Abs. 1910 (1914)] the author has investigated the electric charges on small spheres of air immersed in an aqueous solution of thorium nitrate. The spheres become positively charged in solutions of the salt as dilute as 8×10^{-6} normal. For concentrations in the neighbourhood of 6×10^{-6} normal, a sphere initially negatively charged becomes gradually positively charged as the sphere decreases in size. A sphere of air immersed in colloidal thorium hydroxide becomes likewise positively charged, and the same reversal of sign of the charge is shown as the bubble decreases in size. It is suggested that the reversal of sign affords evidence of a relation between the curvature of the surface and its adsorptive power. **J. S. G. T.**

115. *The Electrolysis of Aqueous Solutions of Alkaline Nitrites with a Lead Anode.* **F. H. Jeffery.** (Faraday Soc., Trans. 17. pp. 709–718, May, 1922.)—An investigation was made of the reactions which occur during the electrolysis of solutions of sodium nitrite when using lead anodes. The cell consisted of a glass dish inside which was a porous pot containing a kathode of smooth platinum. The anode was of an area 50 cm. × 2 cm. and bent into cylindrical form. The current employed varied from 0·099 to 0·77 amp. The lead dissolved at the anode, forming a complex which gave a bright orange colour to the anolyte. Measurements made of the potential difference between anode and solution showed that the degree of dissociation of the complex lead anion was very small. No appreciable change of potential was brought about by varying the current density or the concentration of lead in the electrolyte, and only a small effect was obtained by adding sodium nitrate and varying the concentration of nitrite. In no case was the concentration of plumbous ion sufficient to cause deposition of lead on the kathode. From the influence of varying concentrations of NO_2' and $Pb^{\cdot\cdot}$ ions on the potential difference, it is estimated that the complex formed is of the composition $Pb(NO_2)_4''$. At certain concentrations this is in equilibrium with $Pb(NO_2)_2 . H_2O$ which separates on the anode. The ionic complex is similar to those obtained with silver and copper anodes. [Cf. Abs. 754 1343 (1921).] **J. N. P.**